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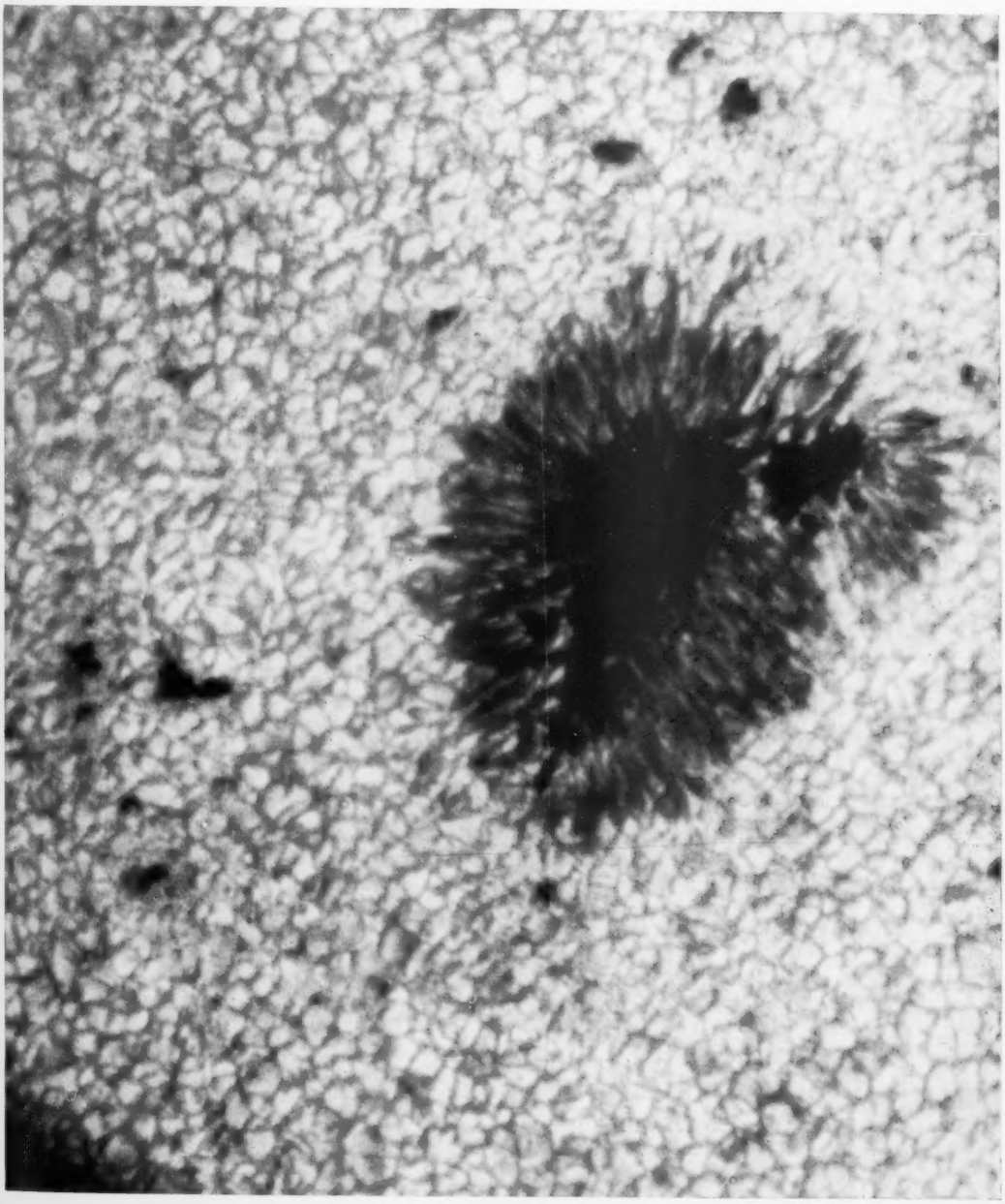

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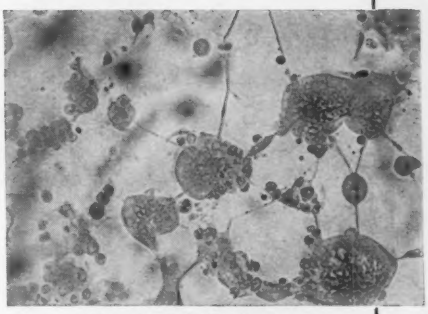

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Cover Sunspot, taken from a balloon at an altitude of 80,000 feet at 11:13 A.M. C.D.T. during the Stratoscope flight of 17 August. Project Stratoscope is an undertaking in high-altitude astronomy headed by Martin Schwarzschild, professor of astronomy at Princeton University, and supported by the National Science Foundation and the Office of Naval Research. The telescope carried by the balloon was designed and built by Perkin-Elmer Corporation, and the television equipment used for controlling the telescope from the ground and for transmitting the images was designed and built by the Princeton Laboratories of the Radio Corporation of America.

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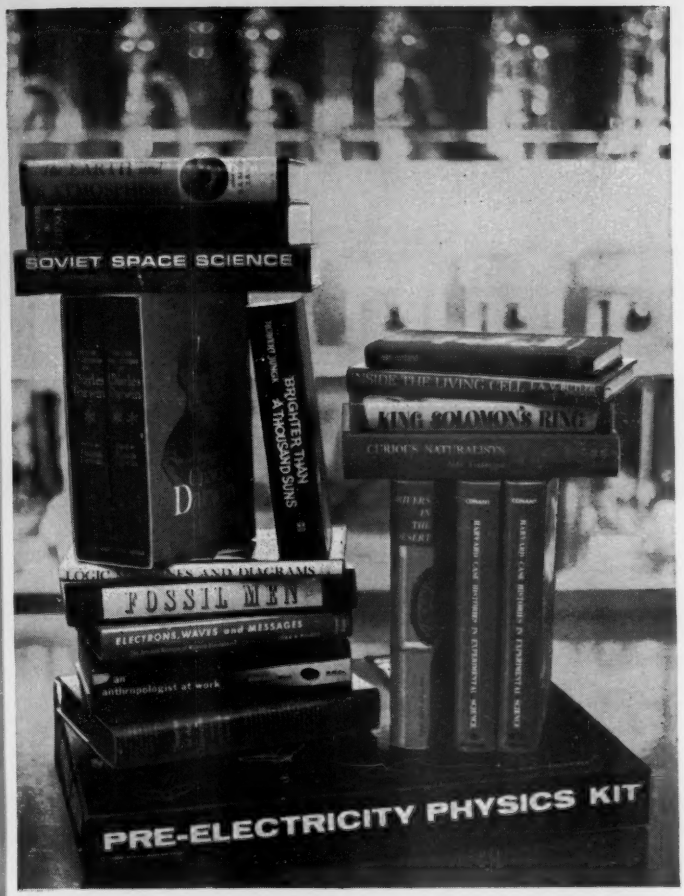

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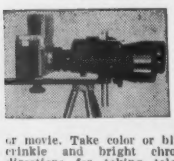

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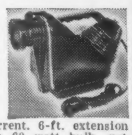

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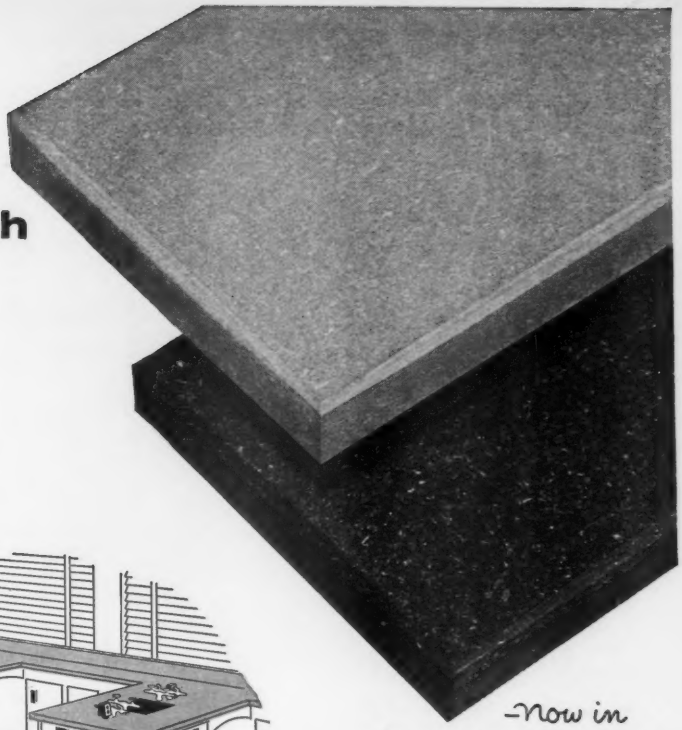

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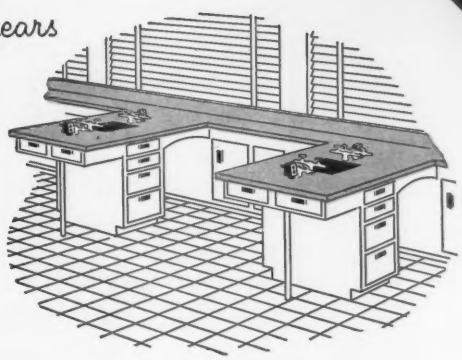

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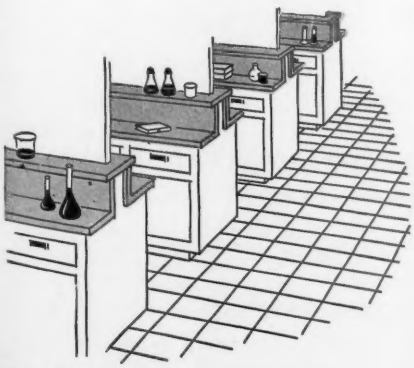

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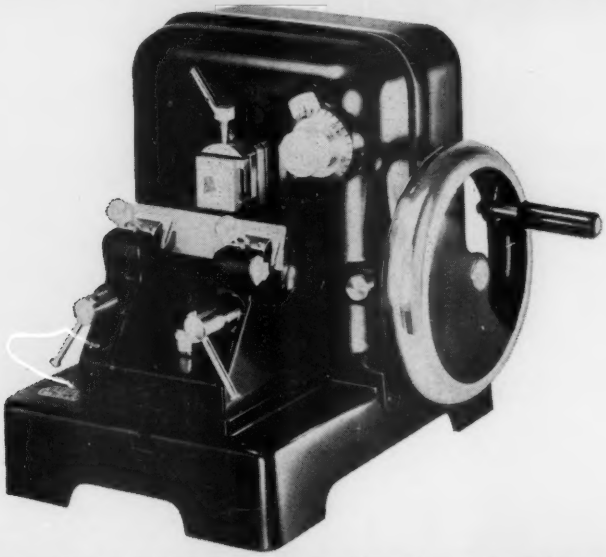

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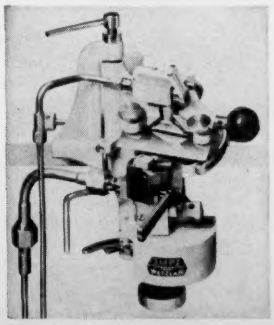

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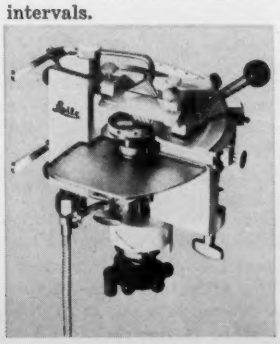

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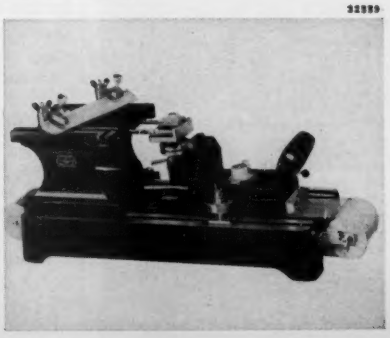

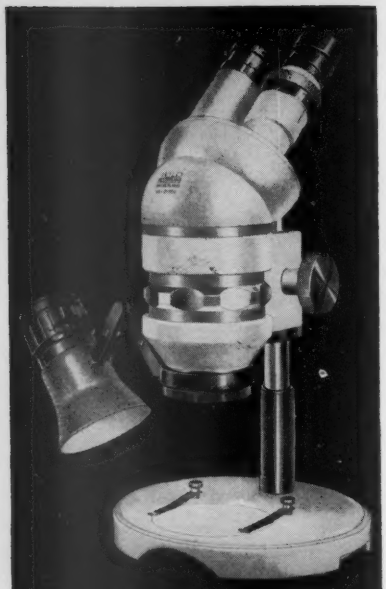

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Letters

Probability, Logic and Medical Diagnosis

Ledley and Lusted [*Science* **130**, 9 (1 July 1959)] have suggested the use of mixed strategies in the treatment of patients. While it may sometimes be useful to know the strategy that would be optimum against an intelligent opponent, a doctor would have to be extremely pessimistic to use such strategy regularly. For example, if treatment T_1 has values 3 for disease D_1 and 10 for disease D_2, and if treatment T_2 has values 4 for D_1 and 3 for D_2, then Ledley and Lusted would suggest settling for the value 3⅞. If, instead, one assumes that in the absence of other information both diseases are equally likely to occur, then T_1 has an expected value 6½ and would certainly be chosen. As a patient, I would far prefer that the doctor follow the latter procedure. The use of mixed strategies in games against nature has frequently been suggested in other fields also and usually seems unsatisfactory.

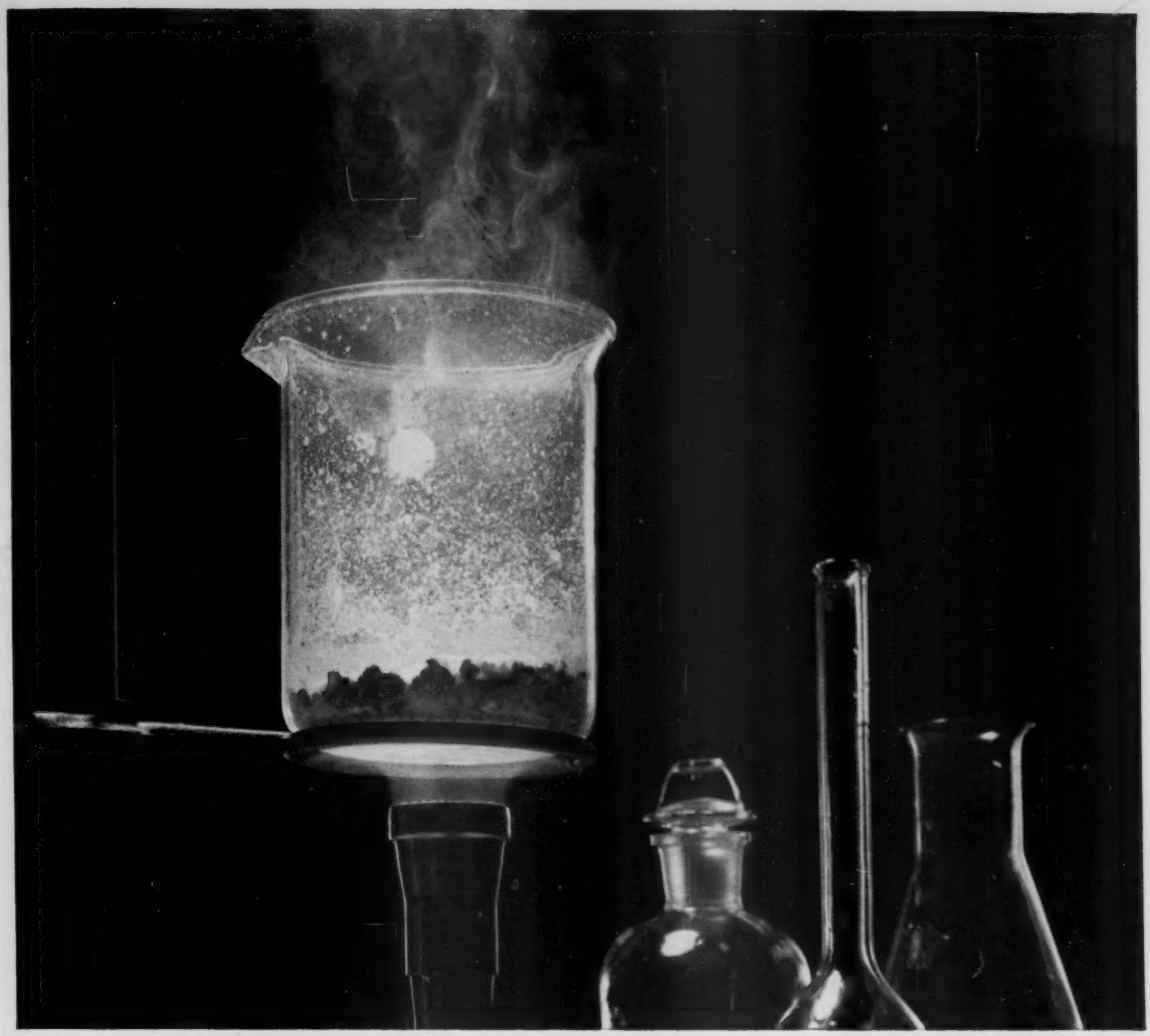
PETER L. BENDER
9606 Bulls Run Parkway, Bethesda, Md.

As a practicing physician who has been interested in the application of Boolean techniques to medicine, I read Ledley and Lusted's article with great interest. The authors' approach to the problem of differential diagnosis is naively simple. Their basic premise appears to be that most difficulties in diagnosis arise because the physician is either not aware of all the possibilities or is insufficiently acquainted with the symptom complexes. While this may be occasionally true, unfortunately most difficulties in diagnosis arise because the patient does not present the *classical* picture. A computer crammed chock full of textbook descriptions of disease, with minute listings of differences in syndromes, will rarely come up with the answer to a difficult problem in differential diagnosis. This stumbling block is fundamental and is inherent in the technical exposition of the authors.

I submit that the authors have handled the data sometimes in the manner of the propositional calculus and sometimes as class algebra, but always as if each variable were universally either true or false. The moment we go from the textbook to the patient, we must quantify. We must say, "some patients having certain symptoms have certain diseases," or even, "sometimes, some of the patients, presenting some of the symptoms, have some of these diseases." Thus, if the statements are properly quantified, the machine will hem and haw like a physician at the bedside.

This is not the time or the place to examine in detail the manner of arriving at a differential diagnosis. Sometimes we deal with diseases which affect many systems; in this case some of the techniques presented by the authors might prove valuable. In other cases a disease affects a particular system, in which case the physician first tries to determine which system is affected (for example, circulatory, respiratory, gastrointestinal) and then tries to pin down the particular entity involved. In many cases it is only by having intimate knowledge of the natural history of the disease, and by following the manifestations as they unfold, that we can arrive at a diagnosis. Many times the symptoms we have learned by rote (and unfortunately there is much of this) completely fail us. The astute physician must fall back upon his knowledge of physiology and disturbed physiology in order to arrive at a logical conclusion.

All this is not to say that a computer approach cannot help us. If a computer were properly programmed, as I am sure it can be, to rearrange medical knowledge into a more useful form, which could then be published, physicians would certainly benefit. A likely approach would be to employ the method of dichotomy. For example, there are probably 30 or more causes for shoulder pain. If we apply a single criterion—that the pain is elicited or aggravated by motion of the shoulder—we can divide these causes into two groups. In the group in which pain is elicited by motion, we apply a second criterion, limitation of shoulder motion and lack of such limitation. In two strokes the 30 possibilities have been reduced to nine. Further grouping on the basis of one or two symptoms would quickly narrow down the range of possibilities. To go through a list of possibilities sometimes enormously larger than this by the method proposed by Ledley and Lusted would require a much greater amount of time and work than the method of dichotomy. I should like to quote from a recent textbook (*1*): "If the set U were to contain 2^{20} (approximately 1 million) logical possibilities and we were able to ask yes-no questions in such a way that the knowledge of the truth value of each question would cut the number of possibilities in half each time, then we could determine with twenty questions any possibilities in the set U." Ashby (*2*) gives an even more striking description of the value of dichotomy. Another likely application for Boolean algebra in medicine would be to simplify criteria for diag-



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nosis. The prototypes of this approach are the well-known Venn "club rules" problem (*3*) and the so-called simplification of insurance rules (*4*). Much more could be said about this approach.

Finally, the suggestion that game theory concepts be applied to medicine is an excellent one. It is a pity, however, that the authors, who quote Williams in another connection, do not mention the fact that his remarkable little book published in 1954 put forth this very same suggestion (*5*).

MILTON KUNIN
9410 South Western Avenue,
Los Angeles, California

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1. J. G. Kemeny, J. L. Snell, G. L. Thompson, *Introduction to Finite Mathematics* (Prentice-Hall, Princeton, N.J., 1958), p. 81.
2. R. Ashby, *An Introduction to Cybernetics* (Wiley, New York, 1957).
3. Quoted in J. T. Culbertson, *Mathematics and Logic* (Van Nostrand, Princeton, N.J., 1958).
4. E. C. Berkeley, "Boolean algebra (the technique for manipulating 'and,' 'or,' 'not,' and conditions) and applications to insurance," *Record Am. Inst. Actuaries* **26**, pt. 2, No. 54, 373 (1957).
5. J. D. Williams, *The Compleat Strategyst* (McGraw-Hill, New York, 1954), p. 122.

The concept of mixed strategies is one of the fundamental concepts embodied in Von Neumann's so-called "game theory." When the strategy of the opponent is *unknown*, a mixed strategy on the part of the proponent will *minimize his maximum loss*. The concept does not require that the opponent be intelligent, as P. L. Bender seems to believe, but rather that the proponent has *no* information about what the opponent will do. If a patient has either disease D_1 or D_2, and if we have no further information, probabilistic or otherwise, then why assume that the chances of his having one disease or the other are equal? Why not assume that the chances are nine out of ten that he has D_1? With no information, the assumptions are equally valid—or, more precisely, equally invalid. As a matter of fact, the article observes that, "in actual practice, some further information bearing on the choice of treatment would be sought—that is to say, the formulation of the problem of which treatment to give the patient is far more complicated than that posed by the single problem discussed above." We then go on to quote J. D. Williams: "Perhaps its [the mixed strategy and game theory's] greatest contribution is . . . the general orientation given to people who are faced with overcomplex problems."

In replying to Milton Kunin, we first want to thank him for his interest in our work. The exposition given in our article was intended for readers who are not primarily mathematicians, but this should not lead Kunin to believe that our treatment of the subject is "naively simple." This is far from true, and judging from Kunin's letter many of the nonsimple aspects of our article evidently escaped his observation. In no way did we imply that the computer should be crammed "chock full" of textbook descriptions of diseases. In fact we devoted a whole section to the "Conditional probability or learning device," suggesting that the computer "learn" from current statistical experience (which of course it will compile from *nonclassical* as well as classical diagnostic "pictures"). It is this statistical experience that comprises the "medical knowledge" often referred to in the article. We even considered in some detail the effects of time and location on such statistical records and noted in the "Conclusions" that such a technique "emphasizes the greater significance and value of current statistics; it depreciates the significance of past statistics." Hence, Kunin's implication that "a computer crammed chock full of textbook descriptions of diseases" is a "stumbling block . . . inherent in the technical exposition of the authors," besides being irrelevant, is simply incorrect.

Another not-so-simple point evidently missed by Kunin is the relationship between logic and conditional probabilities. He seems to imply that we have not taken into account that only "some of the patients having certain symptoms have certain diseases." However, a large portion of the article is devoted to such conditional probabilities of patients with a certain symptom complex having a certain disease complex. In fact we open the section on "Probabilistic concepts" with the following remarks: *"Need for probabilities.* In the previous section we considered statements such as, 'If a patient has disease 2, he must have symptom 2.' While such positive statements have a place . . . , it is also evident that in many cases, the statement would read, 'If a patient has disease 2, then there is only a certain *chance* that he will have symptom 2—that is, say, approximately 75 out of 100 patients will have symptom 2.' Since 'chance' or 'probabilities' enter into 'medical knowledge,' then chance, or probabilities, enter into the diagnosis itself." The use of probabilities and the use of logic are not mutually contradictory, as Kunin seems to imply. In fact the propositional calculus of symbolic logic is one of the cornerstones of the theory of probability.

Finally, Kunin suggests that we use the "method of dichotomy," to use his words. Kunin is correct: The application of symbolic logic to the reasoning foundations of medical diagnosis as described in our article is *precisely* the

(Continued on page 930)

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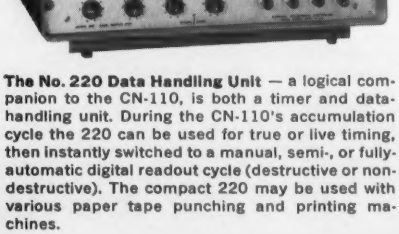

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Use of the Ocean

While few of us are ever satisfied about the state of knowledge in our own particular area of interest, the papers presented at the first International Oceanographic Congress demonstrate that collectively we really do know a great deal about a great many aspects of marine science.

So rapidly is science advancing that in a relatively few years it can be expected that we will know enough about the seas for engineers to begin to make this knowledge of practical benefit to mankind on a considerable scale. It is obvious, I think, that we will soon be able to exert a significant measure of control on climate. We certainly are in a position today to suggest means whereby the winds could be aided in the overturn of the oceans so that the total biological resources could be increased. After all, it is a great deal easier to turn over water than to plow land. Thus it is no longer necessary to suppose that fishermen must always remain hunters rather than farmers.

As scientists we are glad that until now nobody has seriously suggested that we begin tinkering with nature, but this is something that could obviously happen rather quickly, provided there were some agreed principles of control and monitoring. It is high time that some wise and farsighted men begin to think seriously how the vast potential resources of the ocean can be divided on an equitable basis.

The sea is the only part of the earth that nobody claims to own. The old idea of the freedom of the seas has well served its original purpose. It arose because until now the most important characteristics of the oceans were that they provided for cheap world-wide transport and for national defense. I am afraid that the idea of the freedom of the seas is somewhat incompatible with their efficient and wise exploitation.

The economic and social problems that will be encountered as we begin seriously to exploit marine resources seem to me to be formidable, much more formidable than the remaining unsolved scientific problems. Some very wise agency needs to be developing the ground rules within which the vast marine resources can be developed in an efficient and safe manner for the benefit of all mankind.

Inevitably it will be practical to set up the equivalent of fences in the sea so as to regulate the goings and comings of fish. It will be possible to remove the "weed" forms and to encourage the production of desirable food fishes. But probably nothing will happen in such directions on a large scale until it is decided who will have a right to reap the harvest.

Many of us have quite clear-cut ideas about ways by which the oceans could be exploited and at the same time be made more useful to mankind. It is time that the lawyers and the statesmen go to work so that these achievable improvements in the over-all economy can become a reality.—COLUMBUS O'D. ISELIN, *Woods Hole Oceanographic Institution*. [Based on remarks at the concluding session of the first International Oceanographic Congress, New York, 11 Sept. 1959]

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CURRENT PROBLEMS IN RESEARCH

Magnetic Storms

From satellite data should come new understanding of magnetic storms, auroras, and the ionosphere.

E. H. Vestine

The next decade should see rapid progress in our understanding of the nature and cause of the transitory changes in the geomagnetic field known as magnetic storms. We also expect to improve our understanding of related phenomena such as the aurora, cosmic ray time changes, and ionospheric storms.

The reason for this present optimistic point of view is the arrival of the space age, through which an added dimension has become accessible. Rocket- and satellite-borne magnetometers and counters are already extending the measurement of geomagnetic changes and radiation to regions thousands of kilometers above the earth, thereby augmenting human knowledge by providing directly measured data on magnetic storms and auroras in their natural surroundings.

It may be of interest here to recall briefly the history of the study of magnetic storms. Hiorter in 1741 is usually credited with the discovery that the geomagnetic field undergoes occasional changes in intensity on nights of aurora. Even earlier the British astronomer Edmund Halley had ascribed auroras to "magnetic effluvia" constrained to move along the direction of the lines of force of the geomagnetic field within the atmosphere. In view of the very early date, this was a most remarkable exhibition of scientific insight. By about the middle of the 19th century the relationships between electricity and magnetism were better understood. Also, the technique of geomagnetic measurement had progressed so far that it was possible to discover that the amplitude of geomagnetic changes on days of magnetic storm was greater in some years than in others, and that it varies in correspondence with the average number of sunspots. As the magnets suspended by fine fibers moved in response to changes in the geomagnetic field, attached mirrors directed a beam of light onto photographic paper a meter or two away, where the changes in field as a function of time were recorded. These installations were called magnetic observatories. The program of magnetic observatories was begun with instruments devised by the great German mathematician C. F. Gauss (*1*), near the middle of the 19th century. And during the International Geophysical Year, 150 to 200 such observatories, fairly well distributed over the earth, provided especially full coverage, monitoring the magnetic field and its changes with time.

Measurements are made of changes in the magnetic field in the horizontal plane, the horizontal component H of the field intensity being measured along the direction of the compass, and also along the direction perpendicular to H (giving the component of declination D). Also measured is the vertical, downward component Z. The continuous photographic record obtained during a magnetic storm is shown in Fig. 1. The magnetogram for the day shows a sudden change in field value, called a "sudden commencement," which occurs practically simultaneously over the entire earth. The irregular changes in H, D, and Z represent magnetic disturbances or stormy conditions. On a few days each year these periods show especially large field changes with time. These disturbances are classed as magnetic storms.

It is found that departures of the magnetic field from normal depend to a considerable extent on the latitude of the observatory and on the position of the sun relative to the station at various times of day. In addition, a substantial variation with storm time (time measured from the commencement of the storm) is found. Figure 2 shows the storm-time variation averaged for various latitudes for a number of moderate magnetic storms. During the first hour or so the average geomagnetic north force is above normal, only to show a decrease of much greater magnitude some 15 hours or so later. There is then a slow recovery toward the normal, undisturbed value. Changes in east force are relatively smaller, and changes in vertical force also tend to be small and opposite in sign to those in H.

When the storm departures are averaged according to local time, and hence independently of the time of commencement, a diurnal variation is found. The changes near the auroral zones are particularly marked for this variation, which shows a sharp maximum at the auroral zone, and the vertical component shows a reversal of sign as the auroral zone is crossed in latitude.

Electric Current Systems

Data such as those of Fig. 2 have been used by Chapman (*1*) and others to derive averaged electric current systems flowing in electrically conducting regions of the ionosphere in the special case where the ionosphere is regarded as a nearly spherical electrically conducting sheet. Similar derivations have been made, also, for individual hours of particular storms—especially for those of the International Polar Year

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1932–33, because in that year, as in the International Geophysical Year, many additional stations were operating. Figure 3 shows an electric current system derived by Fukushima (*2*) for the Northern Hemisphere, for the main phase of a magnetic storm, for flow of current in the ionosphere causing the departures in magnetic field at ground level. The amount of current between successive current lines is 100,000 amperes. Strong electrojets or concentrations of current flow are shown at the auroral zone, which has expanded southward from its average position during this major part of the storm. During the same time interval other electrojets tend to appear in the southern auroral zones. It will be noted that the electric current rises to about 1 million amperes at the auroral zone. In very great storms current intensities perhaps 5 times as great are known to appear (*2, 3*).

A difficulty with these rather elegant descriptive summaries presented in terms of overhead electric currents is that the form and location of the currents cannot be inferred uniquely from the available data. Hence, a part of the current probably flows at higher levels above the earth, perhaps well beyond the atmosphere, at least in the case of some of these variations. For instance, Störmer (*1*), Chapman and Ferraro (*1*), Bennett (*4*), Singer (*5*), and others have inferred that a part of the current flows in the form of an equatorial current ring at a distance of a few earth radii. This ring current may be broadly distributed in latitude as well. There also appear to be electric currents flowing and decaying several earth radii above the earth. This is regarded by some workers as a logical suggestion because the storm-time variation is often accompanied by the Forbush decrease in cosmic rays. One possible explanation is that the magnetic fields in extensive weak electric currents in the solar corona nearby, in the neighborhood of the earth, slow up or modulate the flux of cosmic rays arriving at ground level during some magnetic storms. However this may be, there is no doubt, from potential theory, that the electrojets shown in Fig. 3 flow mainly within the lower ionosphere, and that the presence there of these highly concentrated electric currents requires explanation. Many of these currents appear almost daily in auroral regions, but their magnetic fields extend only weakly to lower latitudes.

In recent interesting discussions in the literature there have emerged objections to ring-current theories of magnetic storms, as well as uncertainties respecting quite fundamental applications of electromagnetic theory. Parker (*6*) has indicated that the ring-current theory is untenable, since the changing field that it proposes cannot penetrate the electrically conducting ionosphere to reach the ground. In some discussions of this type there has been a return to some early concepts, such as the first theory of Chapman (*7*), which proposed that during the initial phase of storms the earth's atmosphere is compressed and that the atmosphere becomes expanded during the main phase. Hines and Storey (*8*) claim that the ring-current concept remains tenable, since the changing ring-current field can penetrate the ionosphere as a hydromagnetic wave. In any event it has been noted that a substantial part of the sudden-commencement and initial phase has its immediate cause in the lower ionosphere, because the field pattern at ground level is too complicated to arise directly from ring-current sources. The contribution of atmospheric sources to the sudden-commencement and initial phase of storms has

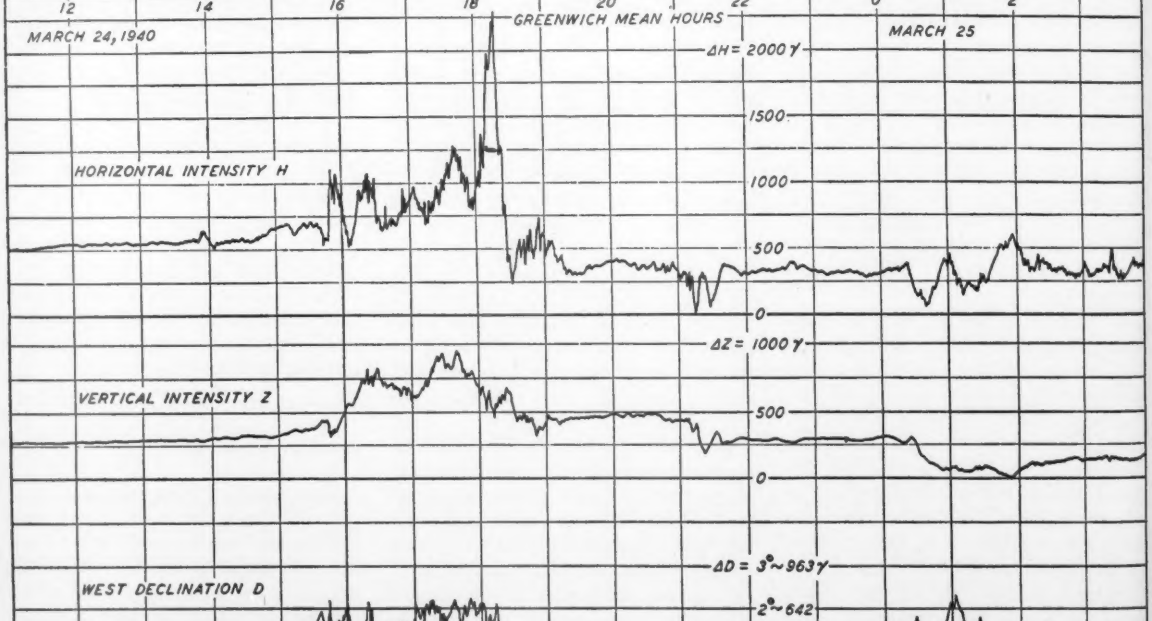

Fig. 1. Wide-range magnetogram, Potsdam-Niemegk, 11 hours Greenwich Mean Time (GMT), 24 March, to 4 hr GMT, 25 March, 1940. [After G. Fanselau]

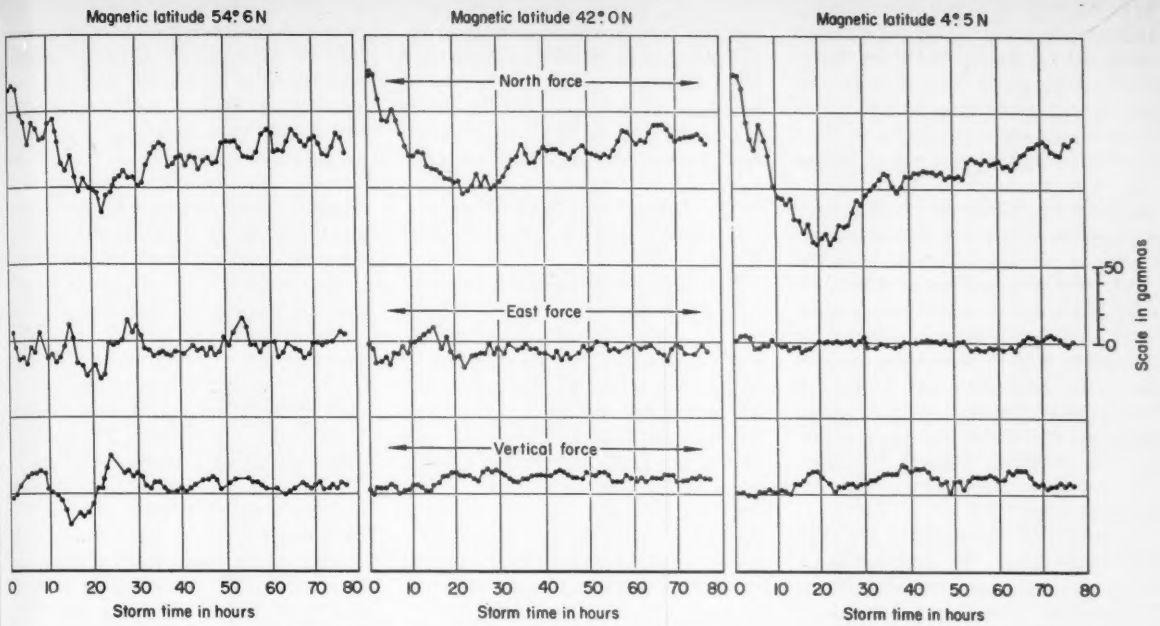

Fig. 2. Magnetic field changes for 11 storms, 1932 to 1933, averaged according to time measured from commencement of the storm.

been emphasized by Sugiura (*9*), Forbush and Vestine (*10*), Jacobs and Obayashi (*11*), Knapp (*12*), and Nagata (*13*). These studies strongly suggest that electric driving forces in auroral regions create electric current systems in the base of the ionosphere, and this conclusion may be checked by noting that the electric fields above these currents in turn lift (or lower) F-region ionization to a measurable degree. In fact, the measured changes in F-region ionization seem in good accord with expectations based on suggestions of Martyn (*14*) made some years ago in a discussion on the action of auroral electric polarization on the world-wide patterns of F-region ionization. It is therefore reasonably clear that the major part of the sudden-commencement and initial phase of storms is strongly contributed to by electric currents near or identified with the highly conducting E-region of the atmosphere.

It has also become clear that the major part of storms in higher latitudes is the S_D part, usually depending mainly on solar position and shown long ago by Birkeland to depend strongly upon electric current in the auroral zone. Hence, though the remaining part—the ring-current part—may arise from hydromagnetic or other action from outside, it seems inappropriate to identify it so all-exclusively as the field of magnetic storms. It is realistic to conclude that the polar disturbance field has atmospheric sources as its immediate and important cause. Martyn (*15*) has suggested, as an extension of the Chapman-Ferraro theory, that charges drain from a ring current into the auroral zones. Ionized solar streams also are supposed to drift past the earth, with a carving out of the Chapman-Ferraro hollow in the solar stream by action of the geomagnetic field to form a current ring. The average auroral zones are regarded as zones to which charges from the ring current drift along the lines of force of the geomagnetic field in producing aurora.

It has also been suggested that electromotive forces originating in the auroral zone drive the so-called diurnally varying part of magnetic storms (*16*). The manner in which the polar electric fields arise to drive the electric currents of the auroral zone is not known.

One suggestion is that upper-air winds may play a part in accord with the Stewart dynamo theory (*17, 18*). According to this theory, the electric field E arises at least in part from a contribution $\mathbf{v} \times \mathbf{H}$, where $\mathbf{v}$ is the wind velocity and $\mathbf{H}$ is the geomagnetic field. Incoming clouds of ionization entering along lines of force of the geomagnetic field into auroral regions must also add considerably to the electric conductivity there. Hence, unless one proposes the absurd possibility that no E-region winds appear over the polar cap, a part of polar disturbance must be wind-produced during magnetic disturbance, though it need be only a minor part. Another part must arise as a result of differential penetration of charges along the geomagnetic field lines, as suggested by a number of workers (*10, 12, 19*). Martyn (*15*) estimated that the ring current should be at a distance of about five earth radii in order to provide drainage of charge into the auroral zone, but he did not succeed in tracing the consequences in the development of the auroral electrojets. The emphasis of Martyn and Alfvén upon drainage of charge into the auroral zones from a ring current is probably a major contribution to the clarification of the cause of magnetic storms and aurora. In support of this view it may be mentioned that my own calculations of geomagnetic field lines in space indicate that in fact the average northern and southern auroral zones appear to be linked by geomagnetic field lines. Also, the intersection of these field lines with the equatorial plane is an oval varying in radius from 5.6 to 5.8 earth radii.

Sudden Commencements

Associated with the larger-disturbance field changes discussed above are associated changes and pulsations of various kinds, including the sudden commencements of storms. In the case of sudden

commencements a mechanism based upon the propagation of shock waves has been suggested by Gold (*20*) and discussed by Singer (*5*). In the case of sudden commencements of storms there is evidence of the existence of intense and strongly localized fields at the auroral zone; this finding tends to encourage the view that differential penetration of charge near the E-region and below provides the surge in electric current required. The oscillatory character of the pulse shows a capacity for reversal in field. In other cases the sudden commencement field is not so highly localized and could be associated with electric currents near the E-region or at much higher levels. It is not yet possible to determine the height of principal current flow.

It has also been suggested (*21, 22*) that propagation of hydromagnetic waves into the ionosphere is important as a cause of various regular pulsations. Van Allen (*23*) and others have suggested that the Van Allen radiation belt may be the source of auroral, magnetic, and ionospheric disturbances. They have stressed the similarity in effects in high latitudes, measured in rocket-borne counters, and in the Van Allen radiation belt discovered with earth satellites. Ionospheric effects of energetic radiation have been noted (*24*). Discharge of plasmas from the radiation belt reservoir must occur if additions from sources, solar and terrestrial, are irregular in time or in substantial amount. Geomagnetic field gradients will affect plasma motion (*25*).

One intriguing possibility is that solar streams impinging on the highest reaches of the terrestrial atmosphere may substantially affect the geomagnetic field lines in a manner depending upon the density and velocity of the stream. The geomagnetic field lines on the dark side of the earth may be bent during the night in the direction away from the sun, thus reducing the intensity of the magnetic field in the upper atmosphere. In this way the particles in the radiation belt may be able to penetrate to lower levels of the atmosphere while reaching their mirror points before spiraling upward along the lines of the geomagnetic field. A concept of this kind may, for instance, be useful in explaining the maximum that occurs in auroral displays near midnight. Unstable drainage of the radiation reservoir may occur even as the reservoir is being replenished, in the event that the solar streams distort and weaken the geomagnetic field locally by their tendency to drag the field lines into regions of lesser field intensity. As the stream intensity increases, more widespread drainage should occur. In fact, as the strong westward-directed electric currents flow along the auroral zone, the geomagnetic total intensity just to the south will be further reduced, and this will lower the Störmer mirror points for particles. North of the electric current the mirror point will be higher, and this might make auroral rays possible. This may in turn result in an expansion southward of the aurora, the electric current, and the associated radio blackout area. An interesting possibility, therefore, is that the atmospheric component of magnetic disturbance may be linked to plasma oscillations within the radiation belt, which are perhaps related to pulsations in field sometimes actually noted during disturbances. According to this view, magnetic bays may develop from drainage of the radiation belt deep into auroral regions, with expansion of blackout regions southward after lowering of the mirror points for reflection of electrons and protons due to weakening of the field of the electric currents. Then, after maximum expansion of the auroral zone currents southward has been reached, discharge from the radiation reservoir may stop, to start again the following evening when the geomagnetic field is again suitably oriented relative to the solar stream. Actually, of course, storage and drift motions of auroral particles within the outer Van Allen region may be only temporary, extending over periods of minutes to hours, say, the main supply reservoir being the nonuniform solar stream itself. The latter may endure for several days during each solar rotation, and there may be more than one such stream.

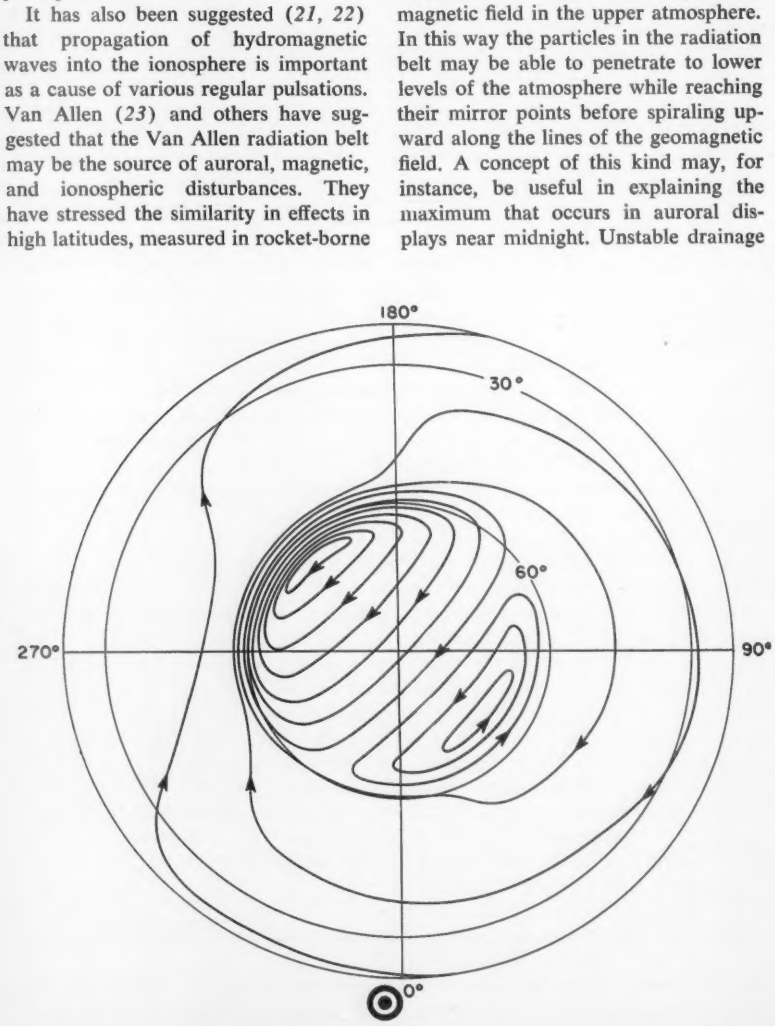

Fig. 3. Instantaneous electric current pattern of storm, at 16 hr 50 min GMT, 1 May 1933; 100,000 amperes flow between successive current lines. (View from above North Pole.) [After Fukushima]

New Opportunities at Hand

Rockets and satellites will soon provide means of locating the various electric current systems in the atmosphere and in adjacent space through direct measurements. These measurements will also provide a means of estimating the current densities and the complexities of the electric currents that cause magnetic disturbance. In particular, the

position and strength of ring currents, if any exist, will probably soon be determined. Since the strength of upper-air winds in the ionosphere will also be estimated, the part played by magnetic disturbance resulting from the dynamo action of winds driving ionized air across the lines of force of the geomagnetic field can be determined. The various rather vague theories about magnetic storms now currently studied can then be revised or replaced with others, in order to explain the results of observation. Observations of effects due to meteors, cosmic dust and gases, x-rays and radio waves, and the polar aurora are being ascertained. Hence, new and rapid progress seems inevitable (*25a*).

Current Theories Awaiting Test

It is clear that a number of hypotheses respecting the cause of geomagnetic disturbance require further study (*26*). The Birkeland-Störmer ideas about electric current flowing vertically along the lines of magnetic force of the earth's magnetic field can be tested by rockets or satellites. These measurements may also serve to check some similar hypotheses in the modern version of this theory, as revised and extended by Hulburt and Bennett. The Chapman-Ferraro theory postulated motion of solar streams in the earth's vicinity giving rise to electric currents gathered in the face of the advancing solar stream. These currents were supposed to be caused by interaction with the geomagnetic field. It is clear that this prediction will also be susceptible to early check with magnetometers aboard satellites or rockets (*27*). As the earth rotates through solar gases in its yearly motion around the sun, various electric phenomena will inform the scientist about seasonal changes in the interaction of the geomagnetic field with solar streams. There will also be opportunity to check electrical effects and possible toroidal fields (*18*) because of slippage of the earth's atmosphere and of its magnetic field within the solar corona. In the same way it may be possible to infer whether or not the electric fields within the solar corona suggested by Alfvén will yield auroras and polar and other magnetic disturbances, as well as certain cosmic-ray changes with time; some workers suggest that these electric fields are very small, even negligible. Finally, as knowledge of the upper-air winds is extended, the actual atmospheric component of geomagnetic disturbance will be estimated and related to the various solar processes and flares which are now little understood but which undoubtedly provide some of the radiation responsible for magnetic storms and related phenomena. There are also available extensive new data for relating solar events on a statistical basis to the ground noise level of the geomagnetic field.

The swift advance in technology, scientific knowledge, and understanding that has characterized the present era will be shared in many areas, and, happily, there seems good reason to hope also for the speedy solution of several very puzzling problems of long standing in connection with geomagnetic time changes.

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25a. *Note added in proof.* Since I wrote this account, the article "The universe discloses its mysteries" (*Pravda*, 15 July 1959) has reported that on 2 January 1959 the Soviet moon rocket Mechta detected an electric current layer 20,000 to 21,000 km above the earth's surface, which is of high interest in relation to the ring-current hypothesis for the cause of magnetic storms. Even though a storm was not in progress, the observation is of interest, because it may represent a decaying effect of an earlier storm. Observations of the Van Allen radiation belt were also obtained [see S. N. Vernov, P. V. Vakulov, A. Y. Chudakov, Y. I. Logachev, *Doklady Akad. Nauk S.S.S.R.* **125**, 304 (1959)]. A survey magnetometer carried aboard the Pioneer I space probe on 11 October 1958 apparently did not encounter a distortion of the geomagnetic field near 20,000 km above the earth, as did the rocket Mechta. (See C. P. Sonnett, D. L. Judge, A. R. Sims, and J. M. Kelso, "A radial rocket survey of the distant geomagnetic field," *J. Geophys. Research*, in press.)

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Sterile-Male Method of Population Control

Successful with some insects, the method may also be effective when applied to other noxious animals.

E. F. Knipling

Laboratory investigations (*1*) followed by the successful eradication of the screwworm (*Callitroga hominivorax*) from the island of Curaçao (*2*) have established the value of utilizing induced sexual sterility as a means of regulating insect populations. Progress in the eradication program currently under way in Florida and other southeastern states under the sponsorship of the U.S. Department of Agriculture and the Florida Livestock Board is further confirmation of the soundness of this approach for the control of this pest of livestock.

I have previously discussed the principle involved in control or elimination of an insect species through the release of a dominant population of sexually sterile males (*3*). The purpose of this article is to consider further possibilities of controlling insect and other animal populations through application of the same principle. It is hoped that such discussion will stimulate research leading to broader application of this technique for use against insects and possibly for regulating or for eliminating from problem areas undesirable populations of higher animals, such as rodents, predators, and other wild animals.

These possibilities are based on the following biological principle: The introduction of sexually sterile but otherwise sexually vigorous males, and to a lesser extent females, into the natural population of an animal species will have greater influence in reducing the biotic potential of the population than elimination of the same number of individuals from the population by destruction or removal.

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If this is a valid biological principle, then biologists concerned with the regulation of animal populations might find it profitable to devote considerable research effort to the development of practical procedures for introducing substantial numbers of sexually sterile males of a species into the population rather than to devote all efforts to the development of ways to kill the organisms. The relative effectiveness of the two procedures will depend on a number of factors, including the mating and dispersal habits of the species. Many obstacles to practical application of the sterile-male technique may limit its usefulness. However, full exploration of the method may lead to broader application than is apparent with current knowledge.

Theoretically, the maximum degree of reduction in the biotic potential of the total population of an organism is directly proportional to the ratio of sterile to fertile males. The degree of control that can actually be achieved probably will vary with the species and may fall well below the theoretical maximum because of the many factors involved. However, the potential effect, provided that normal sexual behavior is retained in the males, is much greater than when the conventional procedure of animal population control is followed. This can be shown to be the case even when the effectiveness of the sterile males is well below the theoretical maximum.

Insect Populations

To illustrate the possibilities of the sterile-male method I have established certain hypothetical conditions. On the basis of these conditions, I have calculated the theoretical maximum effect on the populations of insect and other animal species when they are treated in different ways for the introduction of the sterility factor. Research to develop effective and economical ways of achieving a high level of male sterility in natural populations would greatly extend the application of the procedure for pest control. Thus far, the rearing and release of a dominant number of irradiated insects is the only method that has been employed. If a chemical or other satisfactory method of causing high sexual sterility could be developed which could be applied to the natural populations of certain insects, it would not be necessary to rear and release insects, as is now done for screwworm eradication.

The effect of procedures that cause the desired type of sexual sterility in an insect population, in comparison with those that kill the same number of individuals, is indicated in Table 1. The following assumptions are made in this hypothetical model. (i) The female is monogamous in mating habit, and each sterile male in the population is fully competitive with normal fertile males in mating with the normal females. (ii) The sterilizing agent or procedure will induce sexual sterility in 90 percent of the males and females of each generation, and the killing agent will kill 90 percent of both sexes in each generation. (iii) The biotic rate of increase in an untreated population is fivefold in each generation, and the survivors in the two treated populations increase at the same rate. The potentially greater effect of the sterility approach is readily apparent from the figures in the table.

As shown in Table 2, inducing sexual sterility in the natural population by chemicals or other means is even more effective than rearing the insect and releasing a dominant number of gamma-irradiated males, the procedure used for screwworm eradication.

Theoretically, the effects of a treatment that induces sterility in 90 percent of the natural population is much more marked in the first generation than the effect of releasing enough sterile males

Table 1. Theoretical population trends of an insect species subjected to no treatment and to a chemical or other treatment that affects 90 percent of the population (i) by killing and (ii) by sexual sterilization.

Generation	No treatment	Treatment that kills	Treatment that induces sterility
Parent	1,000,000	1,000,000	1,000,000
F_1	5,000,000	500,000	50,000
F_2	25,000,000	250,000	2,500
F_3	125,000,000	125,000	125

Table 2. Theoretical effect on an insect population of chemical treatment that induces 90-percent sexual sterility as compared with the effect on a like population of the release of gamma-irradiated sterilized males in numbers that dominate the natural male population by a ratio of 9:1 (five times the rate of increase from one generation to the next in an untreated population).

Generation	Chemical sterilization	Constant release of gamma-sterilized males
Parent	1,000,000	1,000,000
F_1	50,000	500,000
F_2	2,500	131,578
F_3	125	9,535
F_4	5	50
F_5	<1	<1

Table 3. Theoretical population trends of a monogamous animal species subjected to destruction or removal, in each generation, of 25 percent (i) of the individuals of each sex and (ii) of the females, with return of sterilized males to the environment.

Generation	Untreated population	Destruction of both sexes	Destruction of females and return of sterile males
1	200	200	200
2	300	225	200
3	450	252	181
4	675	284	156
5	1012	320	122
6	1518	360	99
7	2277	405	76

to equal 90 percent of the combined population of fertile and sterile insects. If the initial rate of release of sterile insects remains constant, however, the final result is the same, because in the latter case the ratio of sterile to fertile insects increases as the population declines. The reason for the greater initial effect of a method that sterilizes 90 percent of the natural population is that the total effect in each generation is 99 percent, as compared with 90 percent in the first generation for the population exposed to released insects. As the population declines, the ratio of released sterile insects to the natural population of fertile insects will increase and will soon exceed 99:1. When this occurs, the effect will be greater than that produced by sterilizing a constant percentage of the natural population.

Other Animal Populations

The possibility of controlling animal populations by the sterile-male method is not necessarily limited to insects. Theoretically the method can be applied to any animal. The procedure may have practical application for the control of certain rodents, predators, or other undesirable wildlife or for limiting the rate of increase of large game species in overpopulated areas. The feasibility of using such techniques must be determined by wildlife biologists who are familiar with the life history, habits, and population dynamics of the animals. Many factors will influence the results, and practical application of the method might be limited. However, the possibilities, based on theoretical calculations, are so intriguing that the figures are presented, for consideration by specialists in this field of science.

In managing desirable wild animal species, circumstances arise that make it necessary to limit the rate of increase of the population. The application of the sterile-male method of regulating such populations may be the most effective and desirable way to achieve this objective. Table 3 shows the theoretical population trend of an animal species under circumstances where 25 percent of both males and females of each generation are trapped and removed from the environment, as compared with the trend where 25 percent are similarly trapped but where all the females are destroyed or removed and all the males are returned after treatment in a manner that will cause sexual sterility without otherwise adversely affecting sexual vigor or behavior. The normal untreated population is assumed to be increasing at the rate of 50 percent from one generation to the next.

As indicated earlier, it is assumed that the species is monogamous in breeding habit and that the sterile males released in the population are fully competitive with normal males in mating with the females. It is also assumed that environmental resistance is reasonably constant and that the parent population produces enough progeny to equal in number, at maturity, the original parent population, whereas the original parent population, owing to normal environmental resistance factors, is reduced by one-half. The population trend is projected for seven generations.

Table 3 shows that the removal of 25 percent of both males and females in each generation has a strong regulating effect on the population. However, this rate of control would not maintain a stable population, and the number of individuals would gradually increase.

The greater regulating effect resulting from the return of the sterile males to the environment, in this hypothetical situation, is readily apparent. If the maximum theoretical effect is produced, the population will gradually decline instead of increasing when the males are removed.

It is, of course, doubtful whether the procedure will produce maximum theoretical effects for most animal species, but the presence of substantial numbers of sterile males would certainly exert greater effect than their removal, even for species that are polygamous in mating habits.

The effects of the presence of sterile males in an animal population could of course be estimated in many ways. The hypothetical situation selected for the model in Table 4 clearly indicates the marked advantage of the sterility method over killing as a means of controlling animal populations. In this case it is assumed that it would be desirable to drastically reduce or even eliminate an undesirable wild animal population. The conditions are similar to those in the situation shown in Table 3. It is assumed that each breeding pair produces two young that survive to maturity, and that the original adult population declines by half before the next breeding period. The net increase would therefore be 50 percent.

The elimination of 90 percent of both sexes from an animal population that

Table 4. Theoretical population trends for an animal species that normally increases at a rate of 1.5 when subjected to an intensive control program that destroys or removes 90 percent of the population (i) of both sexes, or (ii) of females, with return of all trapped males after treatment to produce sexual sterility, or with replacement of destroyed males with sterile males from other sources.

Generation	Elimination of both sexes	Elimination of females and return of sterile males			
		Total population	Fertile males	Fertile females	Sterile males
1*	1000	1000	50	50	450
2	150	285	30	30	225
3	225	145	18.5	18.5	112.5
4	337	80	12	12	56
5	506	44	8	8	28
6	759	26	5.8	5.8	14
7	1138	16†	4.5	4.5	7

* Parent pretreatment. † If projected beyond the seventh generation, the population would continue to decline to a low point of 9 individuals in the tenth generation and would then begin to increase.

has reached damaging proportions would no doubt represent an effective control program. However, with a rate of increase of 50 percent in each generation, the population could be expected to rebound rather rapidly. It is interesting to note the complete reversal in the population trend achieved by returning sterile males to the environment. Theoretically, the population will continue to decline at a rapid rate. If a method of animal population control is employed that destroys both sexes, the introduction of sterile males from other sources should of course have the same effect on the population.

The theoretical population trend is projected through seven generations for both methods of control. On the basis of the original assumptions, however, the normal population theoretically would show a further rise beyond the seventh generation, or until maximum carrying capacity of the environment has been reached. In contrast, the population into which the sterile males were introduced would continue to decline beyond the seventh generation. A theoretical low of nine individuals would be reached in the tenth generation, but then the population would begin to increase. If complete elimination was desired, this could be achieved by introducing into the population from other sources a relatively few sterile males after several generations had elapsed. To achieve theoretical elimination through initial control efforts, a reduction of 92 percent of the females and replacement of a like percentage of sterile males would be necessary.

The regulating effect of the presence of the sterile males would be very great even if two sterile males were required to nullify the reproductive capacity of one fertile male. Calculations (not shown) made on this basis indicate that the population trend in successive generations would be 1000, 311, 180, 115, 88, 85, and 103, the low level being reached in the sixth generation.

In support of the possible validity of the estimates of population decline by the sterile-male method given in these hypothetical models, it may be pointed out that eradication of the screwworm on the island of Curaçao was achieved by the fourth generation. The actual population trend was in line with prior estimates, based on calculations of the type presented in this article.

Procedures

If, in fact, it can be shown that a population will respond in a manner approaching the theoretical estimates in Tables 3 and 4, research to develop practical procedures for utilizing this method of controlling or eliminating animal populations seems justified. Procedures that will induce the desired type of sterility in both males and females of the natural population would be the most practical. In the absence of a practical way of inducing sterility in the natural population, the destruction of a high percentage of both sexes by whatever means is most practical and replacement of the destroyed males with sterile males reared or obtained from other sources should be given consideration.

In considering the release of sterile males for regulating animal populations, I believe that it would usually be necessary first to reduce the natural population to a low level so that domination of the natural population can be achieved with a minimum number of sterile males. This might be necessary not only from the standpoint of the cost of providing the necessary animals but also to prevent damage that might otherwise be caused by the animals released. This procedure is believed to offer the most promise for the practical application of the sterile-male technique in insect control. Natural populations of many insects are too high, even at the low point in the abundance cycle, to make it economically feasible to rear and release enough sterile insects to dominate the male population without prior reduction to a low level.

Summary

The principle of animal population control through the use of sexually sterile males has been demonstrated for insects. Sexually sterile males that retain their sexual vigor and behavior will exert greater influence in regulating animal populations than can be achieved by destroying or removing the same number of individuals from the population. This hypothesis is supported by calculations showing theoretical population trends in assumed insect and animal populations subjected to treatments that destroy or eliminate certain percentages of the individuals as compared with a procedure that retains or replaces the same number of males in the population after sterilization. The maximum regulating effect that can be achieved is in direct proportion to the ratio of sterile to fertile males competing for mates.

The advantages of inducing sexual sterility in a natural population of an insect species by chemical or other treatment over the method of rearing and releasing a dominating population of sterile males are considered. It is suggested that the sterile-male method may have practical application for undesirable populations of certain wild animals as well as for insects.

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Science in the News

Transfer of Projects Gives Air Force Major Role in Military Space Activities

A new assignment of areas of responsibility, made last month by the Department of Defense, has given the Air Force the major role in military space activities. The move gave the Air Force responsibility for development, production, and operation of all military space vehicles, including the Saturn booster, the Army's major project.

Secretary of Defense Neil McElroy, in signing the new policy order, effectively removed the Advanced Research Projects Agency from the space systems field. Four satellite programs that had been under ARPA have been assigned to the military services, with the Air Force the big gainer. With the projects will go more than half of ARPA's budget of $455 million for fiscal year 1960.

Programs Transferred

The four satellite projects that were transferred from ARPA to the military services are all in the development stage. The two that were assigned to the Air Force were Midas, a satellite system employing infrared reception to give early warning of ballistic missile attack, and Samos, a system of satellites to be used for reconnaissance. Transit, a project which would use satellites for improved navigation, was transferred to the Navy, the service which had been working on it as the primary agent for ARPA. Responsibility for Project Notus, a large satellite system designed for use in communications, was given to the Army. The project calls for instantaneous and delayed relay of messages by satellites hovering above a fixed point on the earth.

The major program retained by ARPA is Project Discoverer, which is involved more with development of space flight techniques than with purely military objectives. Eventual transfer of this program, probably to the Air Force, is also planned, however. Despite the various transfers ARPA will continue to operate, but with a new role. The agency was established in 1958 to coordinate and manage advanced research projects, particularly those of the military that cut across the traditional service missions. The agency's new role, it is believed, will be to organize basic research in space techniques that will eventually bear on the country's military programs. It will be, the observers suggest, a relatively small technical group to study and evaluate advanced projects.

Civilian Space Agency

These developments in the Department of Defense are expected to have no immediate effect on the National Aeronautics and Space Administration. A call has been made, however, for closer liaison with NASA. The need for a better method of securing such cooperation became evident during Senate hearings conducted last spring by Stuart Symington (D-Mo.).

Informed observers of the Pentagon's various space programs suggest that the new assignment represents the beginning of a slow transformation of the country's military space program from the confused state that became evident during a number of Congressional inquiries to a more orderly and sound state. Congressional pressure, recent Soviet successes, and the influence of Herbert York, defense director of research and engineering, are reported to be the major forces behind the change.

U.S. Specialists Describe Soviet Commitments to Education

Last month the U.S. Office of Education released Soviet Commitment to Education, *a 135-page report of the first official United States education mission to the U.S.S.R., which took place 8 May-6 June 1958. An 11-member team headed by Laurence G. Derthick, U.S. commissioner of education, visited approximately 100 Soviet educational institutions. Excerpts from the report's sections on primary and secondary education, with particular emphasis on science education, follow:*

The one fact that most impressed us in the U.S.S.R. was the extent to which the Nation is committed to education as a means of national advancement. . . . Tremendous responsibilities are therefore placed on Soviet schools, and comprehensive support is provided for them by all segments and agencies of Soviet society. . . .

Wherever we turned we heard the slogan: "Reach and over-reach America." And everywhere, the people seem to respond in the conviction that education, in addition to hard work and the postponement of many creature comforts, is the best means of winning world supremacy.

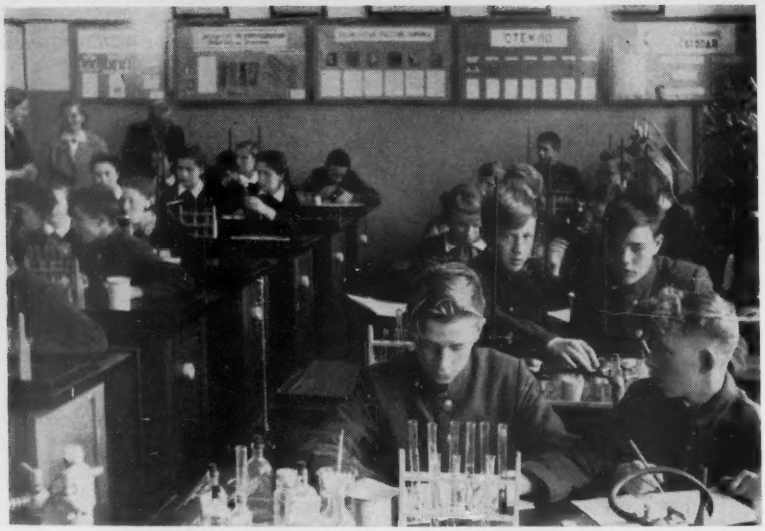
Education reaches far beyond school-age children and youth and is eagerly sought by hundreds of thousands of full-time workers who are also full-time students; hundreds of thousands of others take correspondence courses. Many of these correspondence students also hope to qualify for university entrance. They do this because being well educated is the key to advancement.

And they have been building schools and universities at a rapid pace. Down on the borders of China where only a half-century ago the people were almost 100 percent illiterate, we saw thriving schools, an impressive scientific academy, and other institutions that have reduced illiteracy and advanced knowledge to an astonishing degree. From the shores of the Black Sea to remote Siberia we found the attitude summed up in the expression of a Soviet education official: "A child can be born healthy, but he can't be born educated."

There is still a considerable shortage of buildings resulting in part from . . . damage during World War II. . . .

Administration

Even though education in the U.S.S.R. is controlled by the Government and is therefore standardized and regimented, there is some flexibility of operation. Furthermore, decisions on policy, on textbooks, on teacher training, on curriculum, and on similar matters are not always made arbitrarily. We found fairly widespread evidence that



before making decisions on education, the Government seeks opinions from specialists at all levels of education. . . .

The fact that Soviet educational administration is centralized has often been commented upon. In outward form, however, the Soviet school system is decentralized, with 15 Republic Ministries of Education and many regional and local departments of education. The official pattern before one's eyes is therefore diversity, not uniformity; diffusion, not centralization. This is so even if we disregard the variations deriving from a system of such vast dimensions. Uniformity in educational policies and methods is nonetheless real. . . .

Educational policies (including those on science and research) and administration are controlled at three different political centers by appropriate bodies responsible for these fields: By Federal governmental agencies (ministries and bureaus), by Federal organs of the Communist Party, and by Republic bodies of both Government and Party. . . .

Primary responsibilities for the administration and operation of schools lie with the Ministries of Education at both Federal and Republic levels of jurisdiction and with other governmental agencies concerned with them. . . .

Organization

At the bottom of school organization are the nurseries which serve children up to 3 years of age and at the top the research institutes. . . . Between these two extremes are the main institutions of the Soviet school system: The kinder-

(Top) Laboratory class in a Soviet 10-year school of general education. (Middle) School greenhouse. In urban areas, most Soviet schools have greenhouses; in rural areas each school has a garden plot. (Bottom) Members of the first official United States education mission to the Soviet Union. Henry Chauncey, president, Educational Testing Service, Princeton, N.J.; Laurence G. Derthick, U.S. Commissioner of Education; Harry C. Kelly, assistant director for Scientific Personnel and Education, National Science Foundation; Lane C. Ash, assistant director, Division of Vocational Education, Office of Education; John R. Ludington, director Aid to State and Local Schools Branch, Office of Education; Helen K. Mackintosh, chief, Elementary Schools Section, Office of Education; Herold C. Hunt, Charles William Eliot Professor of Education, Graduate School of Education, Harvard University; A. John Holden, Jr., Vermont State Commissioner of Education; John B. Whitelaw, chief, for Teacher Education, Office of Education. Not shown: George Z. F. Bereday, professor of comparative education, Teachers College, Columbia University, and Oliver J. Caldwell, assistant Commissioner for International Education, Office of Education.

[U.S. Office of Education]

garten, serving children between the ages of 3 and 6; the general education school, offering grades from 1 to 10; and the universities and institutes. . . .

Parallel to the upper 3 grades of the general schools are varieties of technicums and pedagogical schools, which are increasingly giving post-secondary education, and schools for urban and rural youth which offer a general education course to young workers. Other institutions such as labor reserve schools, which teach vocational skills, also provide elements of general education. In addition, educational programs are offered through circles or clubs in Pioneer palaces, camps, and other projects sponsored by municipalities or industrial plants and collective farms.

Financing

. . . While exact figures on the total cost of education annually in the U.S.S.R. are difficult to obtain, it is generally conceded that from 10 to 15 percent of the total national income is channeled into education. . . .

The State budget for education provides for building construction and maintenance, supplies and equipment, salaries of teachers at all levels, stipends for students in institutions of higher education, special programs in education, and miscellaneous expenses. Industrial enterprises and collective farms also provide considerable supplementary support for education, primarily in equipment and facilities. . . .

Schools of General Education

The Soviet system of education is built basically around the general school. . . .

The program of general education consists of 4 elementary school years and 6 secondary school years. A single unified curriculum is planned for the elementary or 4-year school, for 7-year (incomplete secondary), and for the 10-year (secondary). . . .

All general schools are coeducational, attendance is compulsory through the 7th grade, and attendance records are carefully checked. [Under a recent Soviet educational reorganization plan for 1959–1963, compulsory education has been increased to 8 years.]

We were impressed with the abundance of equipment—charts, maps, three-dimensional teaching aids—and by the quality and quantity of laboratory and shop facilities. . . .

The school year begins on September 1 and ends between May 20 and June 20, with a 12-day winter holiday and a 10-day spring holiday. . . . Since the Soviet pupil puts in 6 days a week at school, in 10 years he spends about the same number of days in school as the United States pupil does in 12 years.

Curriculum

The standard curriculum offered in the RSFSR schools is shown below:

Grades 1–3: Russian language and literature, arithmetic, drawing, singing, physical education, and introduction to manual training.

Grade 4: History, geography, and elementary biology—largely nature study—are added to subjects taught in grades 1 to 3.

Grades 5–10: Russian language and literature, foreign language, history, arithmetic, algebra, geometry, trigonometry, physics, chemistry, botany, zoology, anatomy, Darwinism, geography, astronomy and drafting, polytechnical training (agricultural and industrial training), drawing, singing, and physical education. . . .

Mathematics, Russian language and literature, and physical education are required in all grades. Mathematics and science are particularly emphasized throughout the general school. . . .

Only one foreign language is required in the basic curriculum (instruction begins in grade 5 and continues through grade 10), and a pupil has a choice. . . . He may study a second language in an extracurricular language club. . . .

Mathematics and Science

In the 4-year primary school, the arithmetic curriculum is designed to carry Soviet children through a program covering the four operations of arithmetic, . . . real and imaginary numbers, the metric system, the measurement of time, decimals, and the rudiments of geometry.

The mathematics course, which includes arithmetic (grades 5 to 6), algebra and geometry (6 to 10), and trigonometry (9 to 10), is particularly designed for polytechnical education. . . .

Science education for Soviet children includes scientific training through in-school and out-of-school programs. . . .

Science education for Soviet pupils begins in the kindergarten. There a groundwork for scientific habits in the observation of natural phenomena and plant and animal life is laid. . . . In the elementary grades courses in biology, chemistry, and physics are comparable to good elementary science courses in U.S. schools. . . .

Physics—Among the subjects of particular importance is physics, which aims at acquainting the pupil with natural phenomena *and the basic principles of production processes.* The italicized phrase points up an important phase of the Soviet educational system. . . .

In grades 6 and 7 pupils become acquainted with principles of mechanics and heat and electrical phenomena. In grades 8 to 10 the principles of mechanics, acoustics, molecular physics, as well as heat, electricity, optics, and the structure of the atom are covered. . . .

Chemistry—The study of chemistry begins in the 7th grade with elementary instruction on substances and their transformation; on atomic and molecular studies and the principal laws of chemistry; on oxides and the bases of acids and salts; and on the properties of oxygen, hydrogen, the air, and water. After this, pupils prepare for a systematic course in grades 8, 9, and 10, where the work plan calls for a study of chemical elements. . . .

Biology—A systematic course in biology includes the study of botany (grades 5–6), zoology (grade 7), human anatomy and physiology (grade 8), and the principles of general biology (grade 9) which stresses the practical aspects of agriculture. . . .

Astronomy—In the 10th grade an introduction to astronomy is given.

Polytechnical influence—The polytechnical emphasis in the general school has modified the content of physics, chemistry, biology, and mathematics. Science subjects, although important in the training of "future" scientists, now have the major function of establishing an educational foundation for a polytechnical system of training which prepares a large number of students for practical industrial work. . . .

During the last few years the Soviets have been planning, experimenting with, and now are gradually adopting what they call a polytechnical program. The polytechnical program was used in 25 percent of the Soviet schools in 1957–58 in addition to the general education program, which was reduced slightly. In 1958–59 the plan will be followed in 50 percent of the schools. . . .

Teachers

More than 180,000 teachers are employed in schools at all levels in the

U.S.S.R. and all have had some pedagogical training, at least after beginning their careers. . . .

Soviet educators are very much concerned with teaching methods; methods are emphasized in teacher-training institutes, in textbooks . . . , in published literature, and in inservice training. . . .

The teaching we observed, the recitations we heard, and the copybooks we saw indicated that there was much rote learning.

Salaries of teachers in general schools are fixed . . . but the scale varies according to the region and the teacher's position and years of service. . . .

Salaries of beginning teachers are equal in general to those of doctors and engineers, and they can make extra money by increasing their teaching load or serving as group leaders in Young Pioneer circles. Merit teachers get higher salaries or a bonus. There are periodic increases, according to length of service, after 5 and 10 years. Pensions are granted after 25 years, but a teacher with more than 25 years of service who continues to work receives both pension and salary. . . .

All teachers work for 10 months of the year, with a 2-month vacation in the summer at regular pay. They are required, however, to spend 2 weeks in August preparing for the next school year. . . .

In all of the general schools we visited we were favorably impressed by the pupil-teacher ratio and by the number of teaching assistants available. . . .

Soviet school authorities make a determined effort to work closely with parents. . . . We got the impression that generally parents need no urging to cooperate in school activities. . . .

Special Secondary Schools

Considerable attention is given to the preparation of semiprofessional technical personnel in the U.S.S.R.—technicians whose competence lies between that of the skilled worker and the professional specialist. . . . Such workers are trained in special secondary establishments called technicums. Thus there are technicums for training workers for the power industry, the medical profession, light industry, and for others. . . .

Technicums have undergone remarkable growth over the years. In 1914 there were 450 technicums in 72 cities with a total enrollment of 54,000 students and a staff of 4950 teachers. In 1955 there were 3757 technicums in 852 cities with a total enrollment of 1,961,000 students and a total staff of 96,000 teachers.

Teacher Education

Soviet educators are in the process of achieving two major objectives that have in recent years been the concern of our own teacher educators in the United States: (1) To unify all teacher education, and (2) to bring all teacher education to a college or university degree-level status. . . .

In the preparation of both elementary and secondary school teachers, there appeared to be an increasing emphasis on solid subject-matter content, with relatively less emphasis on pedagogy as such.

Soviet teacher educators consider practical work, that is—observation of teaching, student participation in the classroom situation, and student teaching—to be of the highest importance for teachers-in-training for both elementary and secondary schools.

The selectivity in teacher education is approximately 5 to 1; that is, out of approximately 5 students who apply for admission to an institution of teacher education, 1 is accepted.

At this time there appears to be no numerical shortage of teachers in the Soviet Union. . . .

Teachers are not overburdened with extracurricular work. Their clerical duties are minimal. Extra teachers, or tutors, are available to work with slow learners, and to assist generally as teachers' aides. Although schools in the Soviet Union meet 6 days a week, each teacher has 1 work day a week completely free. . . .

Academy of Pedagogical Sciences

Perhaps the most important influence in Soviet educational progress is the Academy of Pedagogical Sciences of the RSFSR, an institution which has no counterpart in the United States. The Academy is the research, development, and resource organization that keeps the educational system moving ahead and improves curriculum and methods of teaching. It is a part of the Russian Republic, not the Soviet Union generally, but as none of the other Republics has such an academy its work is used throughout the country.

Although the Academy is only 14 years old, it is of considerable size and complexity. Its members, who are elected for life, are some of the most distinguished scientists in the U.S.S.R. New members may be proposed by individuals, organizations, or institutions, and are elected every 3 years by secret ballot of members only. It is presently staffed by 34 full members who devote full time to Academy work, 54 corresponding members who devote part time to it, and 550 research workers. The staff is directed by a presidium of 9 members. Members receive a stipend of 3500 rubles a month and corresponding members, 1750 rubles a month in addition to their regular salaries.

The Academy of Pedagogical Sciences has no direct relationship to the Academy of Sciences except that some persons may be members of both and at times members work together in planning research. The Pedagogical Academy also cooperates closely with other academies, like the academies of medicine and of agriculture.

It maintains 8 research institutes, 7 in Moscow and 1 in Leningrad. The 1958 budget for support of these institutes was 44 million rubles, which it received directly from the Government, although its budget is presented by the Minister of Education. It may request additional money from time to time. . . .

Of the many aspects of the work of the Academy of Pedagogical Sciences, three are of particular interest—the development of textbooks, the development of teaching aids, and the work of the department of comparative education [which studies education programs in other countries]. . . .

Due very largely to the work of the Academy of Pedagogical Sciences, education in the U.S.S.R. is not static but is constantly changing and improving.

Conclusion

We cannot afford to be apathetic about educational developments in the U.S.S.R. Clearly the Soviet Union is bent on overtaking and surpassing us as a world power, and it proposes to use education as one of the primary means of obtaining this objective. . . .

We want to emphasize that what we saw in the U.S.S.R. only served to renew our confidence in our better schools. But, at the same time, what we saw increased our concern for our poorer schools, suffering from neglect.

In the light of all we saw, we cannot stress too firmly our conviction that our nation must never forget nor underestimate the power and potential of education.

Machine Programming of Large Meetings To Be Tested

Better planning of large scientific meetings through the use of data-processing techniques may result from a recent National Science Foundation grant. The Federation of American Societies for Experimental Biology, Washington, D.C., will undertake to develop and test machine methods of scheduling the thousands of scientific papers read at large meetings of professional and academic societies. Resulting techniques are expected to greatly reduce the magnitude and complexity of the scheduling process. With the very large number of papers now submitted to most scientific meetings, and with the limited time available for programing, it has become increasingly difficult to build good sessions and to avoid conflicts of interest.

A trial of machine methods will be made in programing the federation's 1960 meeting, to be held 11-15 April in Chicago, Ill. Both the mechanical and the traditional systems will be used, and the two resulting programs will be compared and evaluated. At the 1959 meeting, 2383 10-minute papers were scheduled for 235 separate sessions held during a 5-day period.

Under the trial machine system, authors will be given coding sheets and will classify the subject matter of their papers. These papers will then be automatically grouped and assigned to sections. The subject classification assigned by authors and punched on cards may also serve as a subject index.

Industrial Laboratory Directory Being Prepared by NAS—NRC

The National Academy of Sciences-National Research Council reports that the eleventh edition of its directory, *Industrial Research Laboratories of the United States,* is now being compiled and will be published in mid-1960. The volume, published periodically since 1921, is expected to contain descriptions of approximately 6000 scientific and technological laboratories, many of them established since the publication of the previous edition in 1956.

More than 25,000 questionnaires are being mailed by the Academy-Research Council in search of appropriate data for inclusion in the volume. A cut-off date of 1 February 1960 has been set for their incorporation in the 11th edition; all responses arriving after that date will be held for a subsequent edition.

As in the past, the directory will list only nongovernment laboratories devoted to industrial research. For the purposes of this directory, however, "research" will include industrial development work on processes and products as well as fundamental and applied research. In addition, laboratories concerned primarily with routine testing and control, but conducting research activities, will be listed.

Each entry will contain the name and location of the laboratory, the types of research performed, the availability of services to others, and the names and number of professionally and technically trained personnel of the scientific research staff. The number of nonprofessional employees will also be given.

There is no charge for listing in the directory. Any research organization which has not received a questionnaire by 5 November but which wishes to be included in the new edition should inform Walter M. Whitlow, Editor, *Industrial Research Laboratories,* National Academy of Sciences-National Research Council, 2101 Constitution Ave., NW, Washington 25, D.C.

Diploma Mills Damage United States Prestige

Diploma mills calling themselves colleges or universities and conferring "quick-way" degrees, usually mail-order, are taking in an estimated $75 million annually and heavily damaging United States prestige abroad. With perhaps as many as 750,000 "students" annually, many of them in other countries, the bogus educational institutions are causing foreigners to question the integrity and quality of all American education. Many United States officials abroad have reported the problem and appealed for a solution.

In response, the American Council on Education, through its Committee on Education and International Affairs, has published *American Degree Mills,* a 100-page study of the problem by Robert H. Reid. Reid reports finding at least 200 degree mills operating in 37 states. He divides them into two main categories: (i) American institutions located in the United States and offering study by correspondence at home and abroad, which concentrate heavily on foreign nationals as prospective students (this is the category with which the study is chiefly concerned); and (ii) American-chartered or American-sponsored institutions located on foreign soil that offer residential or correspondence education to foreign nationals and to some Americans. A third, but less prevalent, type is the American institution located in the United States which offers "patently inadequate" residential study to foreign students who come here on student visas.

In considering possible solutions to the degree-mill problem, the report reviews the efforts of many agencies, public and private, to find an answer. A major factor, the report says, is the fact that:

"The United States unlike most other countries of the world, has no ministry of education. State laws chartering institutions of higher education are not uniform and are actually quite lax in controlling educational malpractice. Furthermore since there is no single yardstick for accreditation, this system is especially difficult to explain to nationals of other countries, who simply cannot appreciate that a country can have educational standards unless there is a federal agency controlling such matters."

Recommendations Offered

In its section on conclusions and recommendations the report declares that the solution demands better legal machinery than now exists, and proposes the following steps.

1) There is a basic need for concerted action by the states leading to the adoption of uniform legislation that sets minimum standards for the licensing and operation of all institutions of higher education—with special control of degree-granting privileges. Responsibility for administering such standards should be vested in the appropriate state educational authority. Such action should go beyond the passage of the law. It must provide sufficient staff and resources to ensure periodic review and continuous enforcement of these standards. The means for carrying out this first step exists. The Council of State Governments has indicated not only a keen interest in the problem but also a willingness to proceed immediately toward preparing and recommending uniform state legislation.

2) Even if all the states do pass satisfactory statutes, the need for supplementary federal legislation is apparent, for there will still be loopholes in interstate and international control. It is therefore recommended that, at an appropriate time after the Council of State Governments has had a chance to act, an effort be made to interest a congressional committee in arranging hearings on the need for supplementary federal legislation. A major advantage of such hearings is that they would place on the record, with full congressional immunity, a large body of factual information about these "colleges"—their names and locations, their proprietors and activities—and examples of the serious international implications of their operations. Complete exposure would give additional ammunition to all agencies now frustrated by this problem.

Documentation Unit Formed

The National Academy of Sciences–National Research Council has announced the establishment of a new Office of Documentation, under the directorship of Karl F. Heumann, previously research director at Chemical Abstracts Service. The office will operate in three major areas: it will (i) give advice to the National Science Foundation and others as appropriate in broad problems of scientific documentation; (ii) provide a mechanism for the participation of United States scientists and documentalists in international documentation activities; and (iii) give advice and assistance to the several activities of the Academy–Research Council in the documentation problems they encounter from time to time.

It is anticipated that an advisory panel of scientists and documentalists will be set up to assist the office. Close liaison will be maintained with the NSF's Office of Science Information Service and with other interested groups.

Grants, Fellowships, and Awards

Foreign. The Institute of International Education is reminding prospective applicants that little time remains to apply for some 900 Fulbright scholarships for study or research in 28 countries. Applications are being accepted until *1 November*. Requests for forms must be postmarked before *15 October*. Inter-American Cultural Convention awards for study in 17 Latin American countries have the same filing deadline.

Recipients of Fulbright awards for study in Europe, Latin America, and the Asia-Pacific area will receive tuition, maintenance, and round-trip travel. The IACC scholarships cover transportation, tuition, and partial maintenance costs. The Institute of International Education administers both of these programs for the U.S. Department of State.

General eligibility requirements for both categories of awards are: U.S. citizenship at time of application; a bachelor's degree or its equivalent by 1960; knowledge of the language of the host country; good health; and a demonstrated capacity for independent study. Preference is given to applicants under 35 years of age who have not previously lived or studied abroad.

Enrolled students at a college or university should consult the campus Fulbright adviser for information and applications. Others may write to the Information and Counseling Division, Institute of International Education, 1 E. 67th St., New York 21, N.Y. or to any of IIE's regional offices.

General. Colleges, universities, and nonprofit research and higher educational institutions have been invited by the National Science Foundation to submit proposals for summer (1960) and academic year (1960-61) study-training-research projects designed to provide educational opportunities for secondary-school students, college undergraduates, and teachers. Building on the successful experience of similar projects of the past summer and the present school year which attracted thousands of students and teachers, the foundation plans to continue three experimental programs next year. Proposals from colleges and universities will be considered in all three. They are:

1) *Summer Science Training Program for Secondary-School Students.* This program is designed to encourage scientific interests of high-ability secondary-school students by providing, during the summer of 1960, opportunities for them to study and work with experienced scientists and mathematicians in classrooms, laboratories, and research facilities. Because a primary purpose in this program is to permit superior students to take advantage of the resources of colleges and universities through special programs developed by these institutions and conducted by their faculties, it is expected that a major portion of the instruction will be provided by regular staff members. The deadline for postmark of proposals for the summer of 1960 is *12 October 1959*.

2) (i) *Undergraduate Research Participation Program,* and (ii) *Undergraduate Research Training Program.* It is the purpose of these programs to help colleges and universities provide new and expanded means for high-ability students to advance in their understanding of scientific methods and in their ability to employ investigative procedures.

One means is to introduce more actual research activity into the undergraduate educational pursuits of potential scientists. Such activity typifies the Undergraduate Research Participation Program under which students participate in established programs financed primarily for objectives other than undergraduate education. Another is to make it possible for colleges and universities to initiate new programs with the primary objective of providing educational experiences for undergraduates and financed largely from funds for educational purposes. This method is typical of the Undergraduate Research Training Program. Proposals for these programs beginning in the summer of 1960 should be postmarked not later than midnight *15 November;* those beginning in the academic year 1960–61, not later than *8 January 1960*.

3) *Research Participation for Teacher Training.* This program is designed to encourage colleges and universities to provide research experience for science and mathematics teachers in high schools, and for instructors in science, mathematics, and engineering in colleges (including junior colleges) which have but few, if any, research facilities. The fundamental purpose of the foundation in supporting this type program is to encourage the development of opportunities for the further training of teachers. Training in these cases is to be provided through participation in research activity under the tutelage of experienced scientific investigators. Actual research experience, full time in the laboratory, in the field, or in theoretical investigations, should form the basis of a research participation program. It is expected that teachers participating in such experience will receive individual and special consideration, and that they will be provided guidance which will effectively aid them in obtaining a type

of experience which will enrich their teaching. These are summer programs only, and proposals should be postmarked not later than midnight *26 October*.

Suggestions for the preparation of proposals may be obtained from the Special Projects in Science Education Section, Scientific Personnel and Education Division, National Science Foundation, Washington 25, D.C.

Scientists in the News

The following surgeons were made honorary fellows of the International College of Surgeons during the congress of the college's North American Federation that was held recently in Chicago, Ill.

Mother **Anna Marie Dengel,** superior general of the Medical Mission Sisters of Rome, the first woman to receive the honor. She is the founder of the Roman Catholic medical missionary society and has established 30 hospitals in Africa, India, Venezuela, Indonesia, and Pakistan.

Jean Creyssel of the University of Lyon, France.

Sten A. Friberg, rector of the Karolinska Institute, Stockholm, Sweden.

Rear Admiral **Bartholomew W. Hogan**, surgeon general and chief of the U.S. Navy Bureau of Medicine and Surgery.

Arnold S. Jackson, director of the Jackson Clinic and chief of staff of Methodist Hospital, Madison, Wis.

Donatien Marion, governor of the University of Montreal.

Louis McD. Orr, president of the American Medical Association.

Samuel Rosen, associate clinical professor of otolaryngology at Columbia University.

Curtice Rosser of the University of Texas Southwestern Medical School, Dallas.

Ralph E. Snyder, dean of New York Medical College.

J. Andre Thomas of the faculty of sciences at the Sorbonne, Paris.

Pietro Valdoni, professor of surgical pathology at the University of Rome.

Recipients of honorary membership were: **Cecil J. Birtcher**, maker of electronic medical instruments, Los Angeles, Calif., **Tomlison Fort**, vice president of the Westinghouse Electric Corporation, and **David L. Helfferich**, president of Ursinus College, Collegeville, Pa.

The following engineering scientists recently joined the University of California at Berkeley.

Thomas H. Pigford, chairman of the engineering department at the General Atomics Division of General Dynamics Corporation, has become chairman of the department of nuclear engineering.

Lofti A. Zadeh, associate professor of electrical engineering at Columbia University, has been appointed professor of electrical engineering.

Charles K. Birdsall, former group leader and consultant in electron physics for the General Electric Company and technical specialist with the Hughes Aircraft Company, is associate professor of electrical engineering.

Douglas W. Fuerstenau, manager for mineral engineering for the Kaiser Aluminum and Chemical Corporation, has become associate professor of metallurgy.

Georg Bruun, former faculty member of the Royal Technical University of Denmark and director of the Radio Receiver Research Laboratory of the Danish Academy of Technical Sciences, became acting associate professor of electrical engineering.

Clifford T. Morgan, formerly professor of psychology at Johns Hopkins University, has been appointed visiting professor of psychology at the University of Wisconsin for the academic year 1959–60.

Karl Meyer, professor of biochemistry at Columbia University College of Physicians and Surgeons, received the $6500 T. Duckett Jones Memorial Award during the annual meeting of the Helen Hay Whitney Foundation in Princeton, N.J.

Siegfried Muessig, project chief of the mineral deposits branch of the U.S. Geological Survey, has been appointed chief geologist at the U.S. Borax and Chemical Corporation.

Albert H. Taylor, retired chief consultant in electronics of the Naval Research Laboratory, Washington, D.C., will receive the Stuart Ballantine Medal from the Franklin Institute on 21 October.

L. J. Markwardt has retired as assistant director of the U.S. Forest Products Laboratory, Madison, Wis. He will continue as consultant for industrial concerns in the forest products fields.

William A. Mason, assistant professor of psychology at the University of Wisconsin, and **John M. Warren**, assistant professor of psychology at Stanford University, have been appointed research associates at the Yerkes Laboratories of Primate Biology, Inc., of Emory University, Orange Park, Fla.

Carl O. Dunbar, retired director of the Peabody Museum of Natural History at Yale University, has received the Hayden Geological Award of the Academy of Natural Sciences of Philadelphia.

Walter F. Leverton, assistant manager of the Research Division of Raytheon Company, Waltham, Mass., has been appointed engineering manager of the company's Semiconductor Division.

Recent Deaths

Paul Alexander, Princeton, N.J.; 63; physicist and high vacuum specialist; director of research at the Continental Can Company, New York; 18 Sept.

Rev. **Thomas D. Barry**, Weston, Mass.; 58; head of the astronomy department and professor of mathematics at Weston College; 19 Sept.

Kenneth W. Chapman, Washington, D.C.; 48; specialist on narcotics addiction; associate director of the clinical center at the National Institutes of Health, Bethesda, Md.; 18 Sept.

Abraham Flexner, Falls Church, Va.; 92; educator who revolutionized this country's medical education; founder and director emeritus of the Institute for Advanced Study, Princeton, N.J.; 21 Sept.

George N. Raines, Washington, D.C.; 51; professor and director of the department of psychiatry at the Georgetown University Medical Center and a retired captain, Navy Medical Corps; 16 Sept.

Albert A. Somerville, Carmel, N.Y.; 75; physicist and retired vice president and manager of the rubber products department of the R. T. Vanderbilt Company; 20 Sept.

Gregory Zilboorg, New York, N.Y.; 68; private practitioner in psychoanalysis and psychiatry in New York since 1931; historian of psychiatry and medical psychology; assistant professor of clinical psychiatry at New York Medical College and clinical associate professor of psychiatry at the State University of New York College of Medicine; 17 Sept.

Book Reviews

The Study of Man. Michael Polanyi. University of Chicago Press, Chicago, Ill., 1959. 102 pp. $1.75.

In these three Lindsay memorial lectures, Michael Polanyi summarizes some of his conclusions from the larger book *Personal Knowledge* in order to take some steps forward. In brief, his analysis is intended to show that all knowledge from mathematics and physics through biology to historiography and the humanities has involved in its structure two components, a tacit one and an explicit one, and that all acts of knowing involve both that which is focally seen and that which is subsidiarily understood. Not *everything* within a science or a single proposition can be rendered explicit or seen in the focus of thought. Hence all knowledge involves a "personal commitment," namely, a responsible acknowledgment of one's commitment to those tacit and subsidiary factors which render our explicit and focal knowledge possible. To comprehend or make sense of experience is to organize its detail, seen focally or explicitly, into certain understood, comprehensive entities which make *sense* of the detail. Thus, the "ultimate particulars of nature" are understood by comprehending the *patterns* they form in space and time, and the "passionate intimations of this harmonious order are the guides of discovery in physics, and the beauty of a physical theory is the mark of its scientific value" (page 74). Machines, tools, and living things on the vegetable level are understood through their *purposes* or functions. Animals, the next order, are understood in terms of their *actions*, which are guided by the animals' knowledge, a knowledge which may be correct or incorrect. And man—"whose capacity to think is his most outstanding attribute" (page 11), human thought being "the highest level of reality in our experience" (page 71)—how are we to understand *him*?

This, as the title indicates, is essentially the concern of this book. Accordingly, the first lecture reflects on the question how we think, and thought is taken more or less theoretically. The second lecture finds that the "calling" of man, or the purpose in terms of which he is to be understood as a species, is to engage in "works of the mind." The third lecture, "Understanding history", tries to comprehend man in his historical uniqueness—that is, the decisive world historical personalities who, although there are nobler human types, nevertheless present the most striking instances of human beings whose decisions affected history. But here our logical situation as historiographers is the reverse of that which obtains on the lower levels. In the first instance, we "look down" upon the ultimate particularities of nature—machines, plants, animals. But confronted with the hero of dramatic history, we "look up" to our object (page 97). Our attitude is no longer that of being adequate to an object of lower or equal height; in history we can confront persons whom we admire as higher individuals and, instead of judging them, we judge ourselves by them; they, in their individuality, become as it were the principles by which we understand ourselves and others. Polanyi observes, and it is essential to his argument, that the self-education involved in the "reverent submission to greatness" may "amount to a corruption." But that is part of an intrinsic hazard: "This choice must indeed ultimately fall back on us, since no authority can teach us how to choose between itself and its rivals. We must enter here on an ultimate commitment which coincides essentially with the act of deciding to what extent we should accept as given the social and mental milieu within which we shall deploy our own thoughts and feelings. By recognizing our heroes and masters we accept our particular calling" (page 98).

As I see it, the freshness of Polanyi's thought in the Anglo-American scene is due to the continental influences in it. As Polanyi says, this is an effort to apply Gestalt psychology to questions of epistemology. In addition, there are phenomenological influences, and others deriving from Hegel, Windelband, and Dilthey. Polanyi's personal synthesis of these influences represents a sharp break with positivism and any form of radical empiricism. Polanyi's effort is to show the ingredience of the responsible *person* in his own acts; and one of the significant acts of the person is that of *knowing*. The knower's tacit commitment to certain values is ingredient in what he knows. Knowledge, then, is hardly understood if it is thought to be the registration of sensa and their subsequent mechanical codification into something thought to be "laws." Such a radical positivism is inadequate for even our simplest knowledge. I, for one, find many of Polanyi's analyses important, valid, and most welcome in recalling to our wits, after the positivistic debauch, what knowledge *is*. But Polanyi's work is not merely a lucid and well-written version, in English, of ideas which have had long currency on the continent. Polanyi has shaped it all anew, and shaped it largely in the light of his own concrete, scientific knowledge. Again, a welcome relief from discussions in epistemology which expire in a vacuum of abstraction.

But this is not to say that Polanyi has wholly succeeded. In my review of *Personal Knowledge* [*Science* **129,** 831 (1959)], I advanced the thesis that while Polanyi desires to retain the validity of truth, his theory in its more radical statements, in fact, leaves us with nothing but a desire for validity. We must responsibly *aim* at truth; and this responsible aiming at something valid, at some contact with reality, is itself the only criterion that we *have* it. "A passionate search for the correct solution of a task leaves no arbitrary choice open to the seeker. He will have to guess right, but he must make the utmost effort to guess right. The sense of a pre-existent task makes the shaping of knowledge a responsible act, free from subjective predilections. And it endows, by the same token, the results of such acts with a claim to universal validity. For when you believe that your discovery reveals a hidden reality you will expect it to be recognized equally by others. To accept personal knowledge as valid is to accept such claims as justified, even though admitting the limitations imposed by the particular opportunity which enables the human mind to exercise its personal powers. This opportunity is then regarded as the

person's calling—the calling which determines his responsibilities" (page 36).

What has gone wrong here? By transposing epistemological questions concerning the validity of theoretical claims into psychological questions concerning "claims" and the acceptance of claims," Polanyi has, I suggest, deprived himself of any means whatsoever for defining the *meaning* of a claim to truth. The same thing occurs in his briefly sketched theory of values; when he has finished we are in no position even to define what an authentic value might be; we are left in the hazards of an admiring submission to a greatness which might also be a corruption. Now this, indeed, may be an essential part of our existential situation. But even this cannot be the whole story, since if it were, all talk about real greatness and real corruption would be senseless in principle. If the very *criterion* by which we are to estimate ourselves is one or more historical heroes, what *sense* indeed does it make to talk then of "corruption"? Corruption in *terms* of what? And what sense does it make to talk of validity in knowledge if that notion is dissolved into "acceptances," "claims," and "commitments"? Has not Polanyi so radically psychologized the whole affair that he has deprived himself of the very means by which he might give meaning to the validity he aims at, accepts, and claims? The value of Polanyi's analyses is great; but I find that in its ultimate formulations all dialectical tension between the subjective and objective is lost, an almost inevitable result of confusing the phenomenology of validity with psychology.

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Chemical Engineering Practice. vol. 6, *Fluid Systems, II.* Herbert W. Cremer and Trefor Davies, Eds. Academic Press, New York; Butterworths, London, 1958. xxvii + 600 pp. $19.50.

This latest volume in a series of reference books on chemical engineering practice presents the conventional unit operations of gas absorption, evaporation, fluidization, adsorption, leaching, crystallization, filtration, and centrifugation. In addition, liquefaction and fractionation of gases, as well as refrigeration practice, sublimation, and vacuum freeze-drying are covered. The general topic of colloids is also included.

As in the previous volumes of this work, the author of each chapter has attempted to present highlights and emphasize the practical aspects of a particular field. However, for certain operations two chapters have been included, one on theory and one on practice. This procedure, for example, has been followed in the case of gas absorption and crystallization. Although thorough coverage of each topic included would require a volume the size of the total compilation, the authors have, in most cases, presented useful details, which may be amplified by reference to the extensive bibliography. This is a valuable addition to the chemical engineer's bookshelf, particularly because of its emphasis on technological details.

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Oceanography and Marine Biology. A book of techniques. H. Barnes. Macmillan, New York, 1959. 218 pp. Illus. $7.

Oceanographers have developed a large number of special techniques and devices with which they attempt to investigate the depths of the sea from their research vessels. A review of these methods and instruments, such as this book purports to present, could serve a useful purpose for the general public as well as for the student and professional oceanographer.

The author has deliberately omitted the many kinds of fishing gear, and he does not consider the Aqualung or such devices as the bathysphere and bathyscaphe. Even within these limits, the range of techniques is very great, and it would be too much to expect comprehensive coverage in so small a book. Biologists, to whom the book seems to be primarily addressed, will doubtless find the section dealing with methods of sampling living organisms too cursory and uneven. A number of instruments are very briefly described and illustrated, and a very few are given detailed, at times minute, description. Only in the case of the Hardy plankton recorder is there sufficient discussion of the limitations and advantages of an ininstrument. Biologists may find more satisfactory for their purposes the chapter on measuring such properties of water as currents, temperature, and salinity. Some common, and a few uncommon and outmoded, instruments used by physical oceanographers are briefly described and illustrated. There is, however, no mention of methods for measuring transparency and radiation in the sea, factors that may be of paramount importance to biologists.

The most useful portions of the book are the chapter that deals with the use of sound waves in the sea, in which the use of the echo sounder and underwater sound in marine biology is discussed, and the chapter that deals with photography and underwater television. In the latter chapter is reviewed the recent work in underwater television, in which Barnes himself has been one of the most active participants. These two chapters present some material that it is difficult to find elsewhere in text form.

The text is marred by some digressions, and some of the verbal descriptions of the mechanisms are difficult to follow. A good portion of the figures seem to serve little purpose in such an abbreviated text. There is a bibliography of about 140 titles, none of which is cited in the text.

This book may be adequate as an introduction for the layman to some of the methods of oceanography, but it is too incomplete and too hurriedly written to serve as a handbook of techniques in marine biology and oceanography for the professional oceanographer, and the student is given too little insight into the applications and limitations of the techniques described to be able to use the techniques intelligently.

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Comprehensive Analytical Chemistry. vol. 1*A*, *Classical Analysis.* Cecil L. Wilson and David W. Wilson, Eds. Elsevier, Amsterdam, 1959 (order from Van Nostrand, Princeton, N.J.). xix + 557 pp. $17.50.

This book is the first part of the first volume of a treatise which will eventually comprise five volumes and about 6000 pages. In the general introduction the editors say, "The aim has been to provide a work which will act as a standard reference, self-sufficient in as many cases as possible, and where this cannot be achieved, a work which will be a natural starting point for any analytical investigation."

A chapter entitled "Analytical processes" occupies nearly half the book. It discusses materials, sampling, sta-

tistics, the measurement of weight and volume, solvent extraction, and organic reagents in inorganic analysis. The section on statistics, by E. C. Wood, is exceptionally well written. That on solvent extraction, by G. H. Morrison and H. Freiser, is systematic and concise, yet it contains a vast amount of practical detail.

A 100-page chapter on gas analysis, by A. E. Heron and H. N. Wilson, treats in detail the Hempel and Orsat techniques, as well as newer microanalytical methods, but discussion of gas chromatography has been postponed to a later volume.

Two chapters, each a textbook in miniature, deal with inorganic and organic qualitative analysis, respectively. A plan for the systematic detection of 47 elements without the use of hydrogen sulfide is described here for the first time, by P. W. West and A. O. Parks. Spot tests are discussed, and H. Weisz describes his novel and simple "ring oven" technique for identifying many different elements in a single drop of solution. The relevance of these qualitative techniques to modern analytical chemistry is defended.

A long chapter on inorganic gravimetric analysis follows, written largely by F. E. Beamish and W. A. E. McBryde. The discussion of laboratory techniques is detailed and valuable; the section headed "Reagents" is sketchy, yet it contains an excellent discussion of the solubility of metal-organic precipitates and the kinds of contamination which such precipitates can have. The chapter closes with an account of precipitation from homogeneous solution, by L. Gordon. I wish that a more complete discussion of thioacetamide had been included here.

The emphasis throughout is on practical applications; the book is written for the chemist at the laboratory bench. Theoretical principles are not neglected, however, and there are ample literature citations. There is some overlapping of the topics treated in different chapters, but this is welcome, since the 17 authors write from different backgrounds—from Great Britain, the United States, Canada, and Austria.

I warn every practising analytical chemist and every chemical librarian that he had better become resigned to purchasing each volume of this work as it appears.

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Antonio Meucci, Inventor of the Telephone. Giovanni E. Schiavo. Vigo Press, New York, 1958. 288 pp. $10.

Even though technology is so ancient that its presence or absence serves to distinguish the human primate from the nonhuman primate, the history of technology is still one of the youngest scholarly disciplines. With few exceptions, it is still in the formative stage in which all change and advance is ascribed to a few unique inventors. Efforts have been made to break the hold of this cult of personality, but official biographies, popular histories, and public relations departments tend to perpetuate this oversimplification of how inventions are made and introduced into use.

Consequently, it is refreshing to see an attack on the great-man theory, even if it is only a flank attack that substitutes one man for another. Giovanni Schiavo's book, *Antonio Meucci: Inventor of the Telephone*, seeks to replace the single inventor of the telephone, A. G. Bell, with Antonio Meucci, the man from whom the Bell Telephone Company and Western Union supposedly stole the invention. Meucci was born in Italy in 1808 and remained there until 1835. He then went to Cuba, where he accumulated a considerable fortune through his inventions in electroplating. He moved to New York City in 1850 and supported himself (and, for a brief time, his exiled revolutionary compatriot, Garibaldi) by setting up a candle (and salami!) factory, but his unscrupulous business partners eventually left him in poverty.

Sometime during the 1850's or 1860's, he conceived the idea of the *telettrofono*, or electric telephone, that he sought to patent in 1871, but since he lacked funds he could obtain only a caveat in which he claimed he was working on such an invention. Two facts form the basis of the charges made by some individuals in the mid-1880's that his invention had been stolen: His wife sold his models in 1871 while he was sick; and the papers and experimental model he left with the Western Union in 1872 disappeared.

This book is a black-and-white narrative of these events, obviously directed to a particular audience. Quotations from the legal depositions lend some plausibility to the author's argument, but the evidence is insufficient to make a convincing case. However, the book serves to remind us that invention is a complex social act that is not due to the efforts of any one person, for what one glimpses here is only a portion of a very intricate story that extends from the workshops of many inventors to the Supreme Court of the United States.

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New Books

The Arterial Wall. Albert I. Lansing. Williams & Wilkins, Baltimore, Md., 1959. 268 pp. $7.50. This volume represents an attempt to review the data that are currently available on the structure, function, and chemistry of the major components of the arterial wall. The volume is sponsored by the Gerontological Society.

A Biological Survey of Katmai National Monument. Misc. Collections, vol. 138, No. 5. Victor H. Cahalane. Smithsonian Institution, Washington, D.C., 1959. 246 pp.

Blakeslee: the Genus Datura. Amos G. Avery, Sophie Satina, Jacob Rietsema. Ronald Press, New York, 1959. 330 pp. $8.75.

Curious Naturalists. Niko Tinbergen. Basic Books, New York, 1959. 280 pp. $5.

Diseases of Medical Progress. A survey of diseases and syndromes unintentionally induced as the results of properly indicated, widely accepted therapeutic procedures. Robert H. Moser. Thomas, Springfield, Ill., 1959. 147 pp. $4.75.

Education in the Age of Science. Brand Blanshard. Basic Books, New York, 1959. 320 pp. $4.50.

Experimental Surgery. Including surgical physiology. J. Markowitz, J. Archibald, H. G. Downie. Williams & Wilkins, Baltimore, ed. 4, 1959. 943 pp. $12.50.

Exploring Biology. The science of living things. Ella Thea Smith. Harcourt, Brace, New York, 1959. 731 pp. $5.20.

A Field Guide to the Birds. Giving field marks of all species found east of the Rockies. Roger Tory Peterson. Houghton Mifflin, Boston, Mass., ed. 2, 1959. 314 pp. $3.95.

The Flight of the Small World. Arnold Eiloart and Peter Elstob. Norton, New York, 1959. 255 pp. $4.50. This is the story of the journey across the Atlantic of four Britishers—half way by free balloon and halfway by sea when they were forced down by a violent storm.

Food. The yearbook of agriculture, 1959. U.S. Department of Agriculture, Washington 25, D.C. (order from Supt. of Documents, GPO, Washington 25). 748 pp. $2.25.

Gas Chromatography. A. I. M. Keulemans. C. G. Berver, Ed. Reinhold, New York; Chapman & Hall, London, ed. 2, 1959. 255 pp. $7.50.

Jan Evangelista Purkyne. Czech scientist and patriot, 1787–1869. Henry J. John. American Philosophical Soc., Philadelphia, Pa., 1959. 105 pp. $3.

Reports

Electrical System for Home Conversion and Storage of Solar Energy

Abstract. Energy storage has long been a problem in connection with home utilization of solar energy. A solution which utilizes solar semiconductor cells for conversion to d-c power is proposed. The d-c power is used to drive an alternator which is connected directly across the residential power lines. Thus a-c power is delivered to the power lines when a surplus of power is available in the home and is used in other parts of the power distribution system. At latitude 42°N there is 3 times more yearly energy recoverable than is used by an average residence on the basis of a 10-by-10-m collection area. At the present state of technical development the cost of such a large-area semiconductor solar cell would be prohibitive.

The approximate 1 kw/m² of solar power available at sea level on a clear bright day with the sun at its zenith has attracted considerable attention in terms of methods of utility, and many techniques have been proposed for making use of this energy (*1*). Commercial utilization in metropolitan and urban areas does not appear to be economically attractive because of the cost of the land. Home utilization could be carried out by using roof areas. The major problem here is one of storing energy during periods of peak solar power for use during the night and when the sun is not shining. Systems have been suggested and tried in which energy is stored in specific heat and heat of fusion of water and other suitable chemicals. With these systems a large storage volume is required, together with recirculation of the fluid.

A new energy storage system which has attractive prospects is shown in Fig. 1. In this system, semiconductor cells (*2*) are used to convert the solar power into direct-current electricity. This electrical power is used to drive a d-c motor, which in turn is mechanically coupled to an alternator. The output of the alternator is connected directly across the power lines and is thus always operating at approximately synchronous speed. A rectifier located between the semiconductor cells and the d-c motor prevents any power from flowing back into the solar cells. An auxiliary semiconductor cell is used to monitor the solar power and control the field excitation of the d-c motor at the correct value. With this method of excitation the d-c motor and associated system always represents the optimum load to the main semiconductor cells so as to abstract maximum power therefrom at all levels of solar activity. During periods of significant solar irradiation, the alternator is driven slightly above synchronous speed and feeds power into the power lines to be used locally or, if the local demand is not sufficient, to be delivered to the power lines for distribution. During the time that energy is fed into the power lines, the conventional kilowatt-hour meter is reversed in operation and kilowatt-hours are subtracted. Thus, basically, the storage method used in this system is the power distribution system which generally extends over wide areas of the United States. The distribution system averages out the power demands over the large area encompassed by the interconnected power companies. A similar system for returning power to the utility company was tried some time ago in connection with recovering energy from the wind (*3*). The individual power-generating plants of the interconnected power companies represent potential energy storage points. Under some circumstances a central energy-storage facility such as a reversible hydroelectric system might be required.

Calculations have been made to determine the annual consumption and recovery of energy for a typical resident. Fritz and MacDonald (*4*) have tabulated isolines of average daily solar radiation received on a horizontal surface at the ground for the different months of the year. This tabulated information can be used to compute a yearly energy flux of 1347 kw hr/m² for Detroit, Mich. If Daniels' suggested (*5*) roof area of 100 m² is used and if a semiconductor cell conversion efficiency of 10 percent and a rotary converter conversion efficiency of 75 percent are assumed, the yearly energy available electrically as 60-cy/sec power is 10,100 kw hr. The average yearly consumption of electrical power per residence for 1958, obtained by extrapolating published data (*6*), is 3400 kw hr. Thus, it appears that even at the latitude of Detroit (42°N) the total yearly solar energy available is nearly three times the average yearly energy requirement. More southern latitudes of the United States would be roughly 50 percent more favorable but, on the other hand, a more typical residential yearly energy consumption would also be roughly 50 percent greater and is

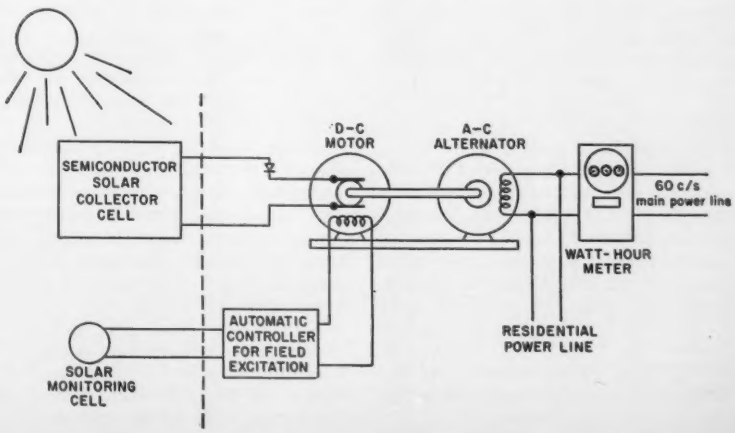

Fig. 1. Solar energy utilization system.

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

currently increasing at 7 percent per year.

If the generated electricity is valued at the current residential rate of 2 ct/kw hr, the solar energy would represent a potential total yearly return of $200. For the system described the peak power capability of the rotary equipment would have to be 11 kw. The costs of the rotary equipment, assuming that an inexpensive induction motor design is used for the alternator, would probably be less than $1000. At the present state of technical development the cost of a large-area semiconductor converter would be prohibited. For instance, the fabrication of a 100 m^2 panel from currently available solar cells would cost in the neighborhood of $250,000. It is worth remembering, however, that this cost is predominately one of fabrication and will be greatly reduced when new techniques—for instance, evaporative methods of fabrication—are developed.

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6 August 1959

Pavlov the Empiricist

I am grateful to Conway Zirkle for his letter [*Science* **128**, 1476 (1958)] calling attention to a 1958 translation of a 1957 article by A. L. Takhtadzhan in *Botanichesky Zhurnal* in which an "article" (Zirkle's designation, Takhtadzhan does not call it so) in a 1927 issue of *Pravda* by I. P. Pavlov on the inheritance of acquired characters is cited. I missed the Takhtadzhan article (the *Botanichesky Zhurnal* is not my usual pabulum), and while I heard of the Pavlov item in *Pravda*, I could not locate the particular issue at the time of writing my article [*Science* **128**, 758 (1958)]. I have now seen the issue (13 May) and would like to report on it and on some related information and interpretation.

Pavlov did not "publish" an "article" in *Pravda*, not even a letter. What happened was that M. Levin reviewed in *Pravda* a 28-page popular pamphlet by E. Smirnov, "The Problem of the Inheritance of Acquired Characters," published by the Communist Academy, and took Smirnov to task for patent bias in favor of the inheritance of acquired characters and for including the Pavlov experiments as alleged positive evidence for it (that was in 1927). Levin stated: "The problem of Pavlov's mice has been taken off the docket by Pavlov himself. Comrade Gutten addressing Academician Pavlov on the significance of his experiments [on inheritance], recently received from him an unambiguous answer. Here is what the conscientious scientist, used to heeding seriously the requisites of the methodology of the natural sciences, writes:

1 March 1927

'Most esteemed Mr. Gutten:

The first experiments with the hereditary transmission of conditioned reflexes in white mice have not yet been confirmed with improved methods and stricter control, so that I should not be classed among those authors who affirm such transmission.

With true respect,
Iv. PAVLOV.'"

Again, I should like to note that my article did not say that nothing was published in Russian about the inheritance experiment before 1949. What it said was that Pavlov's report of it, published in 1923 in four places in English, did not appear in Russian before 1949. The experiment itself was communicated to the 1923 Russian physiological conference by Studentsov, who actually performed it and published it as an abstract in Russian in the *Fiziotogichesky Zhurnal S.S.S.R.* [**7**, 312 (1924)]. The data in the Studentsov abstract differ slightly from those in Pavlov's report: Studentsov reports 298, 114, 29, 11, and 6 conditioning trials for the five successive generations versus Pavlov's rounded figures of 300, 100, 30, 10, and 5.

Zirkle, like B. Gruenberg whom he quotes and like a number of other American scientists, tends to attribute Pavlov's initial acceptance of the inheritance data to "an over-zealous assistant" (presumably Studentsov, who, incidentally, appears to have ended—and begun—his scientific career with the experiment, there being no published mention of him since then). It seems, however, reasonable to assume that Pavlov would not have been so gullible if he had not shared the Lamarckian predisposition, common to Russian bioscientists—and to the intelligentsia in general—even before the Revolution, and if he had reviewed critically the general evidence on the topic; moreover, it might be added that the experiment was performed with mice and not with dogs, and with a "free-running" and not a "harness" technique—both new to the Pavlov laboratory. And these factors, plus Pavlov's sense of his historical destiny as an innovator and tester of nature, were probably the basis of his failure to repudiate formally the inheritance doctrine even after he obtained no evidence in support of it. "Have not yet been confirmed" and "the question . . . must be left open" are the expressions used by him in the aforementioned letter and in the footnote to the 1927 English translation of his *Conditioned Reflexes* (*1*).

Obviously, however, Pavlov's remaining open-mindedness about the inheritance of acquired characters relates little to his status as a thoroughgoing empirical scientist. What does relate is his attitude towards controlling influences of attendant nonempirical sociopolitical and philosophical views. And here Pavlov's record is surely unblemished and strikingly unique and exemplary. He stated in his 1906 Huxley lecture: "Natural science is the work of the human mind directed to nature and investigating nature without borrowing any kind of concept or interpretation from sources other than nature itself" (*2*), and there is not an iota of evidence that in the remaining 30 years of his life he ever in even one instance swerved from the objective. Indeed, just as he resisted any Marxist incursion into his experimental system (*3*), he became in the last years of his life expressly suspicious of what he believed to be distortions of science by religion and other prevailing philosophies. He quotes scornfully Sherrington's saying to him, in 1912: "No, your experiments [on conditioning] will not go over in England because they are materialistic" (*4*), and a later published statement, "*if* nerve activity have relation to mind" (*5*) (italics mine). "Sherrington," Pavlov declared, "is a dualist definitively dividing his being into two halves: a sinful body and an eternal, immortal soul" and assuming that "the brain is a piano, a passive instrument, from which the soul, the musician, can extract any melodies it likes" (*6*)—and he proceeds to label similarly a number of other Western scientists as dualists and animists. Whatever the merits of the labels (*7*), there is no doubt that Pavlov was in all respects an unstinting and uncompromising empiricist and objectivist in a pioneer area in which others often succumb and stray. Perhaps, indeed, he was the 20th century's empiricist par excellence.

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7. In one place (*ibid.*) Pavlov states: "I simply assume that he [Sherrington] is ill, although he is only seventy years old, that these [his views on brain and mind] are symptoms of old age, decrepitude" (Pavlov was 84 at the time). And later, discussing religious-philosophical distortions of science, he concedes: "Take my wife—she is a dualist. She is religious yet she shows no distorted attitude towards things" (*ibid.*). (The excerpts are from informal talks which Pavlov did not prepare for publication, and probably he never thought they would be published.)

7 July 1959

Effect of Dietary Fats on Fatty Acid Composition of Human Erythrocytes and Chick Cerebella

Abstract. Through gas-liquid chromatography it can be shown that increasing the ingestion of linoleic acid-containing fats increases the deposition of linoleic acid in erythrocytes and in brain tissue. Such changes are probably causally related to the tocopherol requirement, the incidence of chick encephalomalacia, and the peroxide hemolysis test. Whether similar mechanisms are involved in the ability of unsaturated oils to lower serum cholesterol levels remains to be determined.

Although it has been generally acknowledged that the composition of depot and plasma lipids can vary with the type of fat ingested, it had not been proved that structural lipids, such as are found in brain or in the stroma of erythrocytes, could also be varied by diet. This report shows that such changes do take place and that they may have physiological significance.

The controlled dietary regimen of the patients whose blood was used in this study was described in previous publications (*1*, *2*) in which the effects of fats on the tocopherol requirement of man were reported. Chick brains were obtained from birds which were fed tocopherol-deficient diets containing lipids with different levels of linoleic acid. The production of encephalomalacia in chicks, with characteristic gross and microscopic cerebellar lesions, depended upon the concentration of linoleic acid-containing fats in the diet, as well as on the absence of tocopherol (*3*, *4*).

Five-milliliter samples of centrifuged packed red blood cells were washed three times with 0.16*M* NaCl and hemolyzed with water (after the addition of 0.2 ml of 0.5-percent *dl*-α-tocopherol to minimize peroxidation), and the lipids were extracted with methylal-methanol (4+1). The lipids were dried under nitrogen, extracted with petroleum ether according to the method of Morris *et al.* (*5*), and methanolyzed according to the procedure of Stoffel *et al.* (*6*). Saponification of blood lipids followed by methylation of the fatty acids gave results which were similar to those obtained by direct methanolysis. Individual cerebella from brains of 1-month-old chicks were similarly prepared after homogenization in methylal-methanol solutions. Most of the methyl esters were chromatographed at column temperatures of 208°C in the Lovelock ionization chamber (*7*) on Apiezon M glass columns having efficiencies of 6000 to 10,000 plates, calculated for methyl stearate according to Desty's method (*8*). The columns were 8 ft long, with an internal diameter of 1 mm. The celite used was 150 to 200 mesh; argon gas pressure was 110 lb; gas flow was 8.5 ml per minute; and time required to complete analyses through C_{22} was 9 hours. The absence of significant amounts of products larger than C_{22} was confirmed through the use of columns containing the succinate polyester of diethylene glycol (*9*) and of high-temperature (300°C) silicone columns with thermal conductivity cells as detectors (*10*). Retention volumes of methyl esters of fatty acids obtained on Apiezon M were similar to those reported by Insull and Ahrens (*11*).

Some of the analyses of chick cerebella were conducted on Apiezon L columns, which required lower gas pressures and took less time for complete analyses, but fewer separation plates were achieved with these faster-acting columns. The resolution of all known fatty-acid components was not obtained by the techniques used. For example, the "linoleic acid" peak includes any linolenic acid which may be present, and the "oleic acid" may contain other C_{18} monoenoic isomers.

As to fatty-acid content, erythrocytes from 19 subjects who for 2 years received a controlled diet of 2300 calories containing 60 gm of corn oil were compared with those from eight patients who had received the regular institutional diet ad libitum for the same period (Table 1). An increased ratio of "linoleic acid" to "oleic acid" was observed in subjects given the corn oil diet. Percentages of linoleic acid in chick cerebella were much lower than those in human erythrocytes, but again relatively larger ratios of "linoleic" to "oleic" acids (.078) were observed in samples from chicks on the corn oil diet, as compared with those obtained from birds on the cod liver oil diet (.014). Lower "linoleic"-acid levels were also seen in cerebella from birds which were fed diets containing very little linoleic acid, such as 4 percent coconut oil, 10 percent oleic acid, and fat-free diets, which, incidentally, do not require tocopherol supplementation for normal chick growth. In all cases, both in the series reported and in subsequent experiments, the linoleic-acid content of a given tissue was higher in subjects that had been fed high levels of linoleic acid than in individuals that had received the lower levels of linoleic acid.

The increase in the linoleic-acid content of the erythrocytes in individuals on diets containing corn oil helps explain why it has been so difficult to obtain normal data on the peroxide hemolysis test (*1*) after long-term feeding of tocopherol-low corn oil diets, followed by tocopherol supplementation (*2*), since the rate of oxidation of linoleic acid is about 12 times that of oleic acid. The data on chick-brain fatty acids help to explain the high incidence of cerebellitis in chicks on diets

Table 1. Fatty-acid composition (percentage ± standard deviation) of human erythrocytes and chick cerebella from subjects that had been fed diets high and low, respectively, in linoleic acids. Number of subjects in parentheses.

Fatty acid	Human erythrocytes		Chick cerebella	
	Corn oil diet (19)	Institution diet (8)	4% Corn oil diet (4)	10% Cod liver oil diet (4)
Lauric	0.5 ± 0.5	0.4 ± 0.2	0.2 ± 0.2	0.1 ± 0.1
Myristic	0.8 ± 0.6	0.7 ± 0.3	0.7 ± 0.4	0.6 ± 0.3
Palmitoleic	0.5 ± 0.2	0.6 ± 0.4	1.2 ± 0.2	1.4 ± 0.6
Palmitic	27.2 ± 2.6	30.2 ± 3.1	36.8 ± 3.8	39.5 ± 6.6
"Linoleic"	15.3 ± 1.6	8.3 ± 1.5	2.0 ± 0.9	0.5 ± 0.2
"Oleic"	17.1 ± 1.5	20.4 ± 3.3	26.5 ± 4.1	33.6 ± 2.2
Stearic	19.2 ± 1.4	20.4 ± 1.8	19.4 ± 0.2	17.3 ± 2.4
C_{20} Penta+tetraene	10.0 ± 3.2	10.4 ± 3.6	4.9 ± 3.2	1.3 ± 1.0
C_{20} Triene	2.0 ± 0.8	1.9 ± 0.7	0.8 ± 0.4	0.3 ± 0.1
C_{22} Hexaene	1.1 ± 2.3	1.2 ± 0.7	2.4 ± 2.4	2.3 ± 2.2
C_{22} Pentaene	1.6 ± 1.0	2.1 ± 1.0	2.0 ± 1.9	0.7 ± 0.5
Others	4.7 ± 2.3	3.4 ± 2.2	3.1 ± 1.7	2.4 ± 0.7
Linoleic:oleic ratio	0.90 ± 0.13	0.42 ± 0.10	0.078 ± 0.048	0.014 ± 0.005
Plasma cholesterol	167 ± 36	184 ± 40 (mg %)		

high in linoleic acid-containing fats (*4*) without tocopherol supplementation and also fortify the concept that tocopherol functions as a biological antioxidant, which is apparently required only where strongly peroxidizable lipids are present. Since such lipids are normal constituents of tissue, one would expect to find that tocopherol is required in amounts in some way related to the amounts of such lipids present.

Of some interest is the observation in a current experiment in which an attempt to reduce the high linoleic-acid content of erythrocytes in patients who had been on a corn oil diet is being made by substituting coconut oil for the corn oil. After 1 month on coconut oil (60 gm per day), there has been little change in the relative amounts of linoleic acid in the erythrocytes of these patients—amounts which remain much higher than those found in nonexperimental subjects. Apparently (although final conclusions must await the lapse of more time to permit a complete turnover of the erythrocytes), the ability of tissue to hold onto linoleic acid tenaciously, if other sources of energy are available, conforms with the observation (*4*) that while 2-percent corn oil diets, from which tocopherol has been removed, seldom produced encephalomalacia in chicks, 2-percent corn oil plus 7-percent coconut oil which had been similarly treated produced the same high incidence of encephalomalacia (over 70 percent) that 4-percent corn oil did. One should also be aware that linoleic acid is a variable component of lard (varying from 2 to 12 percent, depending upon what the hog ate), and studies of tocopherol or cholesterol metabolism in which lard is used (*1*) should take the linoleic-acid content of the lard into account.

It is of interest to note that the same lipid mixtures which increase the tocopherol requirement and promote encephalomalacia in the chick (*4*) also reduce the plasma cholesterol levels in the rat (*12*) and in man (*13*).

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25 June 1959

Experimental Evidence in Support of the Dormant Tumor Cell

Abstract. When rats were injected intraportally with as few as 50 Walker-256 carcinosarcoma cells and then examined 5 months later for hepatic tumor growth, none was evident. If, however, 3 months after injection the rats were subjected to repeated laparotomy and liver examination at 7-day intervals, 100 percent had a tumor within a few weeks.

When specific numbers of viable tumor cells are injected into animals known to be receptive to the growth of such experimental neoplasms, a certain number of "takes" may be expected to occur within a given time. It has been suggested that animals demonstrating no such tumor growth have been able in some fashion to destroy the cells injected. That such cells might not be destroyed but will continue to exist indefinitely in a dormant state has been suggested by experimental and clinical evidence (*1, 2*). Few factual data, however, are available (*3*). Dormancy implies "malignant cells which, although remaining alive in the tissues for relatively long periods, show no evidence of multiplication during this time, yet retain all their former and vigorous capacity to multiply" (*1*).

Recently, while investigating factors which might influence the take and growth of artificially induced hepatic metastases (*4, 5*), we observed that rats injected intraportally with small numbers of Walker-256 carcinosarcoma tumor cells failed to show evidence of tumor growth for inordinately long periods of time. The rats might well have been considered free of tumor. If, however, they were subsequently subjected to repeated surgical trauma in the form of laparotomy with liver manipulation, growth of dormant tumor cells occurred, so that 100 percent of the rats demonstrated hepatic neoplasms.

All animals were adult female Sprague Dawley rats weighing 150 to 175 gm at the time of injection. They were allowed to eat *ad libitum* on a stock diet of Chow checkers and water. The preparation of tumor cell suspensions and the technique of intraportal injection have previously been described in detail (*4*). An aliquot of a filtered saline plasma tumor brei was used for cell counting in a fashion similar to that used for leucocyte counting. Proper dilutions of tumor cell suspensions were made so that each 0.5 ml of the suspension to be injected contained either 250 (experiment 1) or 50 tumor cells (experiment 2). The animals were lightly anesthetized with ether, celiotomy was performed, and the animals were injected intraportally via a large mesenteric vein with 0.5 ml of the saline plasma solution containing tumor cells. To insure maximum viability of the tumor cells, no suspension was used longer than 1.5 hours after its preparation. Approximately 30 rats could be injected during this time. After varying periods of time, exploration for tumor was carried out by an aseptic technique. Animals were considered to have a tumor only after gross examination and later confirmation by microscope. All rats grossly free of tumor were reexamined at weekly intervals until growth was evident, or until they died.

In experiment 1, 122 rats were injected with 250 tumor cells each. Groups of 30 were first examined at 2, 3, and 4 weeks after injection, and 32 were inspected at 8 weeks. The results of this experiment are shown in Fig. 1. At first inspection there was no remarkable difference in the number of positives, whether the animals were looked at as soon as 2 or as long as 8 weeks, there being 20, 20, 27 and 16 percent with demonstrated neoplasms. But on subsequent examinations an increasing number became positive, so that after four laparotomies the 114 rats that survived the multiple surgical procedures all had tumors in their livers. In this experiment the finding of major significance was that all animals first examined at 2, 3, or 4 weeks and surviving multiple laparotomy were positive by 8 weeks, whereas only 16 percent of those opened for the first time at 8 weeks showed tumors.

When it was evident that animals showing no tumor for as long as 8 weeks after injection (84 percent) could be triggered into tumor growth by laparotomy and liver manipulation, experiment 2 was performed.

In experiment 2, 50 rats were injected intraportally with 50 tumor cells; 17 were explored for the first time at 12 weeks, 16 at 13 weeks and 17 at 21 weeks. No tumor was present in any of the animals at the time of first examination (Fig. 2) but, with repeated laparotomy between the 12th and 20th

weeks, all surviving animals had liver neoplasm.

These results would indicate that, when as few as 50 tumor cells are injected intraportally and no growth is observed in the liver for at least as long as 3 months, it cannot be assumed that (i) the animal has been able to "cope" with these few cells, (ii) an "insufficient" number for growths has been inoculated, (iii) the cells did not "lodge" in the liver, or (iv) the cells were not viable. It would seem that they did remain in the liver in a viable but dormant state until triggered into growth by some factor or factors still to be elucidated but in all probability associated with surgical trauma with its attendant metabolic alterations. The mechanism involved in under study. It is suggested that cancer cells, alive to begin with, may be enduringly capable of growth if conditions are favorable (*6*).

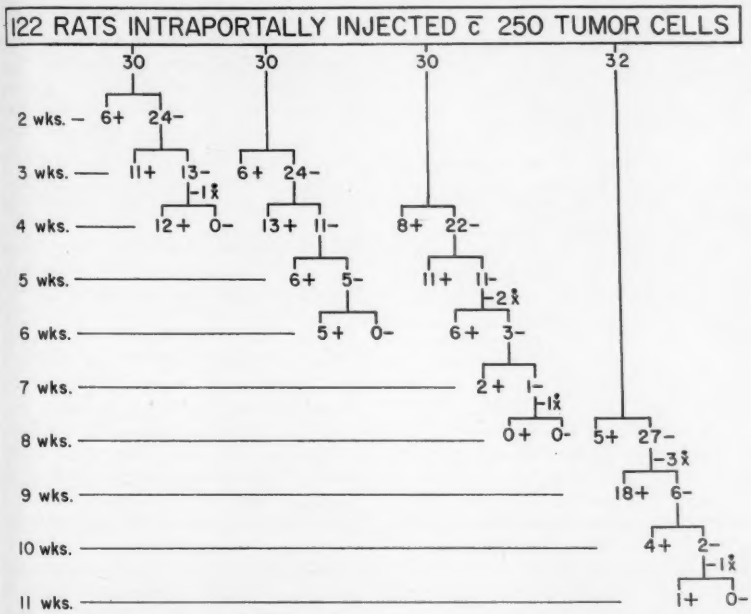

Fig. 1. Effect of repeated laparotomy upon the incidence of hepatic tumor growth following intraportal injection of 250 tumor cells: +, rats demonstrating liver tumor; —, rats free of hepatic tumor; *ẋ*, nonsurvivors.

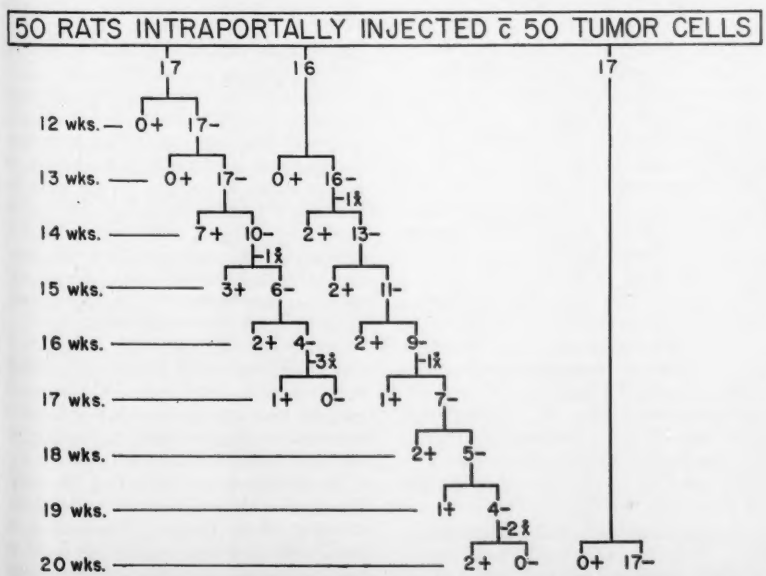

Fig. 2. Effect of repeated laparotomy upon the incidence of hepatic tumor growth following intraportal injection of 50 tumor cells: +, rats demonstrating liver tumor; —, rats free of hepatic tumor; *ẋ*, nonsurvivors.

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* Senior research fellow, U.S. Public Health Service.

20 May 1959

Fusion of Complex Flicker

Abstract. Brown and Forsyth have recently performed a flicker-fusion experiment showing clearly that there is more to flicker than meets the eye. This report presents an analysis of their results which indicates the likelihood that at fusion threshold all but one of the Fourier components of their presentation are imperceptible.

Brown and Forsyth have reported on a very interesting flicker-fusion experiment (*1*). They adopted a presentation extremely well suited to probing the visual processes taking place within a single cycle of flicker. A pulse $(A/2)$ msec long was followed by $(A/2)$ msec of darkness. Succeeding this was another pulse $(B/2)$ msec long, followed by $(B/2)$ msec of darkness. This sequence was continuously repeated. Those values of A and B which gave flicker fusion were then plotted, B against A (Fig. 2 of their report).

This report proposes an explanation of Brown and Forsyth's results and derives some implications from them. The explanation is based on a consideration of the Fourier components of their pulse sequence and on the explicit assumption that the subject discerns any one component at an amplitude which is independent of the presence of other components below threshold amplitude.

This treatment of stimulus components is suggested strongly by the results of de Lange (*2*) and of others cited by him. He presented a spot of constant average luminance modulated in various complex waveforms. For

every waveform, a plot of the amplitude a of the first Fourier component against fusion frequency f gave the same curve. If the higher, subthreshold components had had any influence on a, the different waveforms should have given at least slightly different curves.

The curves given by de Lange approach the form

$$a = kf^q \qquad (1)$$

for a above one-tenth of the average luminance. The method for determining the proportionality constant k is given below. The exponent q appears to lie between 3 and 5, depending on the average luminance and on the observer.

The hypothesis already adduced is that Eq. 1 holds for any Fourier harmonic component of the presentation if that component is the only one at or above threshold. In the waveforms used by de Lange and others, the first Fourier component had the greatest amplitude. It is not surprising that the higher components did not seem to affect the results, especially in view of the strong frequency dependence noted above. However, in the complex stimulus presentation used by Brown and Forsyth, the first component may have too small an amplitude to be perceptible, while the second component may be quite perceptible.

It may be seen that Eq. 1 leads to curves of B versus A at fusion very much like Brown and Forsyth's. If only the nth Fourier component is at fusion threshold,

$$a_n = k(f_n)^q = k\left(\frac{n}{A+B}\right)^q \qquad (2)$$

We have taken $A + B$ as the fundamental period of Brown and Forsyth's presentation at flicker fusion. The value of k may be found from Eq. 1: For the particular case of a pure square wave presentation of average luminance L, the amplitude of the first Fourier component is $4L/\pi$, and the fusion frequency may be written as $1/P$, to use Brown and Forsyth's symbol. Then $k = (4L/\pi)P^q$. Substituting in Eq. 2, we obtain

$$a_n = \frac{4L}{\pi}\left(\frac{nP}{A+B}\right)^q \qquad (3)$$

For the general case $A \neq B$, the amplitude of the first Fourier component is

$$a_1 = \frac{4L}{\pi}\cos\pi\frac{A}{A+B} \qquad (4)$$

and that of the second,

$$a_2 = \frac{4L}{\pi}\sin^2\pi\frac{A}{A+B} \qquad (5)$$

The relation between A and B for fusion of the first component may therefore be found by substituting Eq. 4 in Eq. 3, obtaining

$$\cos\pi\frac{A}{A+B} = \left(\frac{P}{A+B}\right)^q \qquad (6)$$

and for fusion of the second component, by substituting from Eqs. 5 and 3,

$$\sin^2\pi\frac{A}{A+B} = \left(\frac{2P}{A+B}\right)^q \qquad (7)$$

Equations 6 and 7 are much more readily plotted as relations between $(A+B)/P$ and $A/(A+B)$ than as relations between A and B. The appropriate coordinate system is indicated in Fig. 1. In this system $(A+B)/P$ may be plotted against $A/(A+B)$ according to Eqs. 6 and 7 so as to give B/P versus A/P on Brown and Forsyth's axes. Trial values of $q = 3$ and 4 were used in plotting Eq. 6 (the solid curves). The value $q = 4$ fits Brown and Forsyth's data best. It is used in plotting Eq. 7 (the dashed curve). The reflections of the curves in the $A = B$ line are not plotted, to simplify an already crowded figure.

The two $q = 4$ curves fit the data accurately enough to suggest that, as was assumed, responses to different flicker components are largely independent. It is not within the scope of this general analysis to explain the small, but rather consistent, differences between subjects. As well as one can tell from the data, in the fusion region the observer responds independently to whichever component is above threshold.

At the present time more experiments illustrating the visual process postulated here might be of interest. One simple modification of Brown and Forsyth's approach suggests itself—namely, to add luminance modulated sinusoidally at an amplitude equal to that given by Eq. 4, and to adjust its phase for cancellation of the flicker. This would test the sensitivity of the eye to this component and would also allow one to follow the curve represented by Eq. 7 to more divergent values of A and B. The necessary signal voltage could be obtained

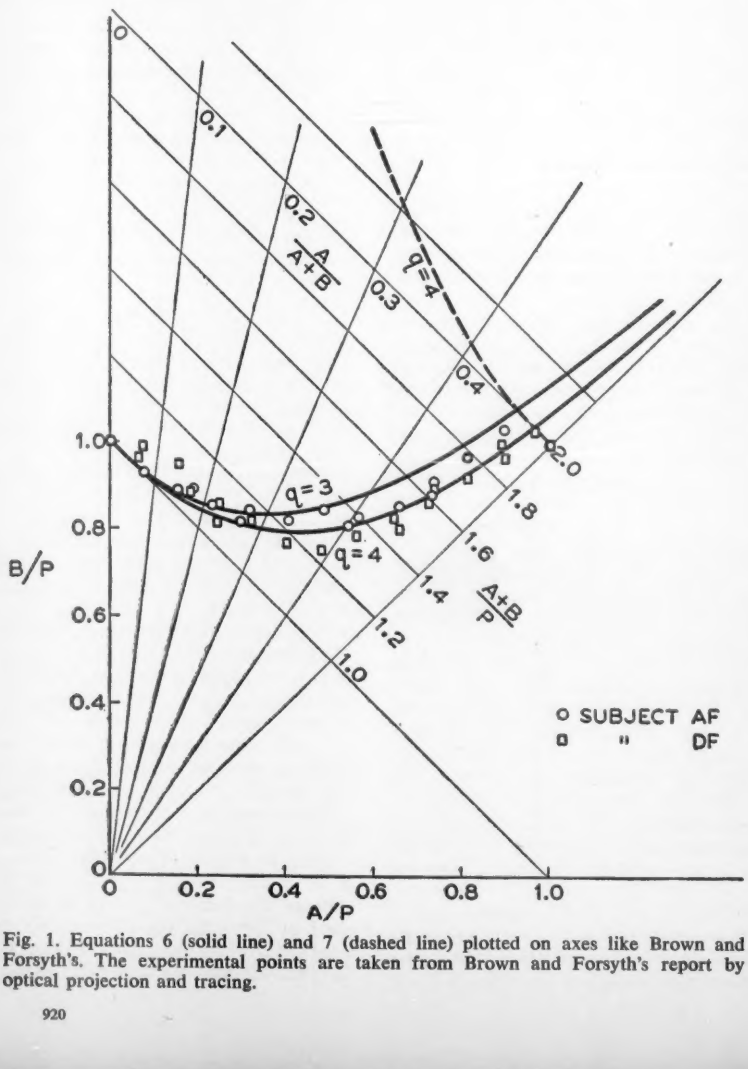

Fig. 1. Equations 6 (solid line) and 7 (dashed line) plotted on axes like Brown and Forsyth's. The experimental points are taken from Brown and Forsyth's report by optical projection and tracing.

from the stimulus control voltage itself and amplified, and its phase could be controlled without change of amplitude by a circuit such as may be found in *Waveforms* (*3*).

One change in Brown and Forsyth's sequence may yet reveal an intracycle effect, namely, the interchange of light and dark phases. The "Metacontrast" (*4*) effect may enhance flicker enough to depress the curves noticeably in the region of small values of A. For best discrimination of change of threshold with interchange of light and dark phases, the presentation could be switched back and forth between the two modes for each setting of A. The difference would certainly be slight, but might be noticeable, especially at lower luminances and frequencies. If noticeable, the effect would qualify the hypothesis of independence of threshold of Fourier components.

Finally, it is possible that an observer could satisfy himself rather directly that he is responding to one or the other of the two Fourier components, for values of A and B near the intersection of the two curves. If B were set slightly greater than P, there should be two nearly equal values of A for which flicker is observed. The flicker frequencies should differ by a factor of 2, very nearly—a difference large enough to be discriminable.

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4 May 1959

Competitive Antagonism between Kinetin and 8-Azaguanine in Polytoma uvella

Abstract. The enhancement of mitotic activity by kinetin is proportional to the dosage from 0.003 to 0.03 μg/ml. This effect is competitively antagonized by 8-azaguanine. The suppression can be reversed by a fresh supply of kinetin.

Kinetin (6-furfurylaminopurine) has been described as a substance which induces and stimulates mitotic divisions in tobacco pith tissue cultures (*1*). Furthermore, it could be shown that, in such kinetin-treated cells, doubling of deoxyribonucleic acid occurs prior to mitosis (*2*). In the course of studies on virulence changes in *Pneumococcus* and *Brucella* it was found that either deoxyribonucleic acid breakdown products or kinetin caused a selective multiplication of virulent cells within a mixed population (*3*). Stimulation by kinetin has been demonstrated in several other biological systems, such as Yoshida sarcoma cells (*4*), *Paramecium caudatum* (*5*), *Euglena gracilis, Ochromonas malhamensis,* yeasts (*6*), *Polytoma uvella* (*7*), and various plant tissues (*8*).

Table 1. Suppression of kinetin effect by various dosages of 8-azaguanine.

Item	Percentage at various concentrations of kinetin					Av. of suppression (%)
	0.003 μg/ml*	0.006 μg/ml	0.01 μg/ml	0.02 μg/ml	0.03 μg/ml	
Effect	+45	+65	+80	+96	+115	
			*Azaguanine + kinetin (1:1)**			
Reduced effect	+32	+50	+59	+75	+93	
Suppression	29	23	26	23	19	24
			Azaguanine + kinetin (10:1)			
Reduced effect	+20	+34	+39	+45	+60	
Suppression	56	48	51	53	48	51
			Azaguanine + kinetin (100:1)			
Reduced effect	+ 8†	+15	+18	+25	+32	
Suppression	(82)	77	78	74	72	75

* The corresponding molecular ratios are 1.5:1; 15:1; 150:1.
† Enhancement of 10 percent or less is of no statistical significance.

Since 8-azaguanine is known to inhibit mitotic divisions (*9*), this purine derivative was tested for an antagonistic effect on the mitosis-stimulating activity of kinetin (*10*). *Polytoma uvella* (WH strain) was chosen as a test organism. This phytoflagellate is a representative of the chlorophyll-free Volvocales; details of its culture and life cycle have been described elsewhere (*11, 12*). The test organism becomes multinucleate prior to cell division; experimental data were therefore collected as nuclear counts. Enhancement of mitosis is expressed as percentage increase of nuclei in treated cultures over untreated cultures after 18 to 22 hours, when the kinetin effect is most pronounced; that is, a 20-hour culture contained 610,000 nuclei per milliliter, while the corresponding kinetin-supplemented culture (0.06 μg/ml) had an increased nuclear count of 1.340 million per milliliter. This is expressed as 120 percent enhancement. Within the range from 0.003 to 0.03 μg/ml, the kinetin effect is proportional to the dosage (*11*). In all the experiments described, 8-azaguanine was used at a level of 10 μg/ml or less; at these levels it is noninhibitory with respect to *Polytoma*.

In the experiments performed to demonstrate antagonism, 8-azaguanine and kinetin were tested simultaneously in varying dosages (Table 1). It may be seen that the degree of suppression of kinetin enhancement depends on both the level of kinetin and the level of azaguanine. These findings indicate a competitive antagonism.

We have also been able to demonstrate the reversibility of the antagonistic effect. A set of cultures grown for 18 hours with 0.3 μg of azaguanine and 0.03 μg of kinetin per milliliter exhibits a suppression of 48 percent. Upon the addition of a fresh kinetin supplement (0.1 μg/ml), the suppression is markedly relieved by the 20th hour and is no longer evident at the 22nd hour.

The fate of 8-azaguanine in living systems has been the topic of numerous studies, recently reviewed by Markham (*13*). This antimetabolite may replace guanine in nucleosides, in nucleotides, and in nucleic acids, or it may block a guanine-containing coenzyme system. Bergmann and Kwietny (*14*) have recently shown that kinetin is converted into 2,8-dihydroxy-kinetin by xanthine oxidase, and they discuss the possibility that "kinetin may react similarly to adenine in other enzyme systems." However, Kalckar *et al.* (*15*) found that inhibitors of xanthine oxidases did not influence the kinetin effect. We believe that kinetin is converted enzymatically to a still unidentified product, as is indicated by the observed competitive antagonism between kinetin and 8-azaguanine.

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30 July 1959

Generator Potential of Insect Chemoreceptor

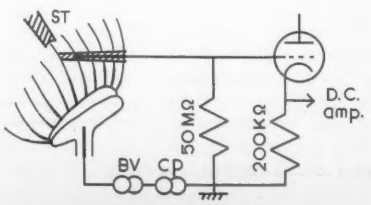
Abstract. Depolarization of the receptor membrane was recorded in labellar chemosensory hairs of flies upon stimulation by sucrose or NaCl. On the other hand, hyperpolarization was recorded in the case of $CaCl_2$, quinine, and acetic acid, all of which had an inhibitory effect on the initiation of chemosensory impulses.

It is now generally believed that in all kinds of receptors sensory impulses are initiated by changes in graded local potential (generator potentials) which are evoked by adequate stimuli. As for taste receptors, generator potential has not been recorded in either vertebrates or invertebrates (*1*). Labellar chemosensory hairs of flies have a structure which makes it possible to record this primary physiological process of chemoreception.

The recording arrangement is shown at the top of Fig. 1. This is an improvement over earlier methods (*2*). The hair wall near the tip of a labellar chemosensory hair of *Calliphora vomitoria* was pierced with a microneedle. At this point the fluid surrounding the sensory fibers inside the hair made contact with the 0.125*M* solution of NaCl contained in a capillary, whose diameter was about 30 μ. Through a platinum wire inserted into this capillary, the electrical activities of the sensory fibers near the hair tip were fed into a direct-coupled amplifier. After these procedures, a stimulating solution contained in another capillary was brought into contact with the hair tip. Movements of this capillary were controlled by an electromagnet and synchronized with sweeps of an oscilloscope.

Figure 1*A* is the record obtained by stimulating a chemosensory hair with a 0.25*M* solution of sucrose. It may be observed that after a brief upward surge, a negativity (downward deflection) is sustained during the stimulation, accompanying a train of impulses. We conclude that this negativity, as well as the impulse, represents a physiological event but that the initial surge is an artifact, since the negativity and the impulse almost disappeared but the initial surge was still recorded after the hair was crushed at the recording point (Fig. 1*B*). In no hairs was a *train* of impulses without a sustained negativity ever recorded; the negativity increased in magnitude with increase in the strength of the stimulus. Thus, it can be assumed that this negativity is the generator potential (depolarization of the receptor membrane). Such a potential was also obtained with NaCl.

It is interesting to note, on the other hand, that a positivity (hyperpolarization of the receptor membrane) was



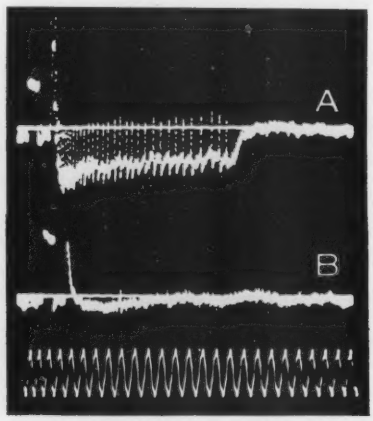


Fig. 1 (Top). Recording and stimulating arrangement. *ST*, Capillary containing a stimulating solution; *BV*, voltage source for balancing the potential difference between electrodes; *CP*, calibration pulse generator. (Bottom) *A*, Response to 0.25*M* sucrose; *B*, application of 0.25*M* sucrose after the same hair was crushed. Just before chemical stimulation, a rectangular calibration pulse of 1 mv (positive with reference to the ground) was applied. Time base, 60 cy/sec.

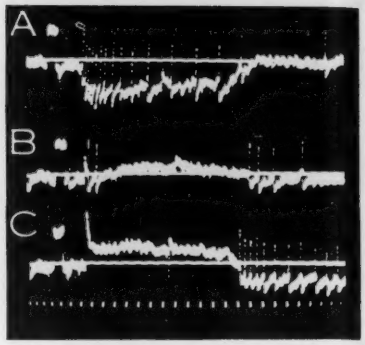


Fig. 2. Response of a hair to 0.25*M* sucrose (*A*), 0.25*M* sucrose + 0.05*M* $CaCl_2$ (*B*), and 0.05*M* $CaCl_2$ (*C*). Time, 1/60 sec.

produced by application of $CaCl_2$, acetic acid, quinine, and other compounds. These chemicals inhibited the initiation of impulses which might be evoked by sucrose or NaCl. One of these results is shown in Fig. 2. In Fig. 2*A*, a chemosensory hair responded to 0.25*M* sucrose in the same way as in Fig. 1*A*. When a mixed solution of 0.05*M* $CaCl_2$ and 0.25*M* sucrose was applied, a slight negativity with a few impulses was induced during the initial period of stimulation, but the negativity soon changed to a positivity, and the impulses disappeared. After the test solution was withdrawn, the positivity turned into a slight negativity, and impulses recurred (Fig. 2*B*). When a plain 0.05*M* $CaCl_2$ solution was used, the positivity and the afternegativity accompanied by the discharge of impulses were clearly observed (Fig. 2*C*). Enough other results have been obtained to show that the membrane potential of the chemoreceptor surface at the hair tip controls the initiation of impulses somewhere near the hair base (*3*).

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16 June 1959

Association Affairs

AAAS Chicago Meetings, 1868-1959

The original object of the Association, now just entering its 112th year, was ". . . by periodical and migratory meetings, to promote intercourse between those who are cultivating science in different parts of the United States . . ." Beginning with the first meeting of September 1848 in Philadelphia, until well into the 1900's, the meetings were the prinicpal activity of the Association. Though *Science* became the official journal of the Association in 1900, ownership and responsibility for its publication did not come until 1938. The annual meeting is still a major activity of the AAAS.

Prior to this year there have been 125 national meetings, but the number does not correspond with the age of the Association. There was no meeting in 1852 ". . . because of the prevalence of cholera along the approaches to Cleveland from the South." The Civil War caused the interruption of meetings in the years 1861–65, and World War II made impossible meetings between December 1941 and September 1944. These lapses, however, were more than offset by the extra summer meetings held in other years, principally within the period 1931–41. Until 1902, the annual meeting was almost always held in August. In that year, the week immediately after Christmas was selected, partly to accommodate certain participating societies and partly because of the increase in the number of academic summer schools.

Each annual meeting of the Association brings together scientists from all fields of science. Each meeting includes sessions arranged by the AAAS as a whole, sessions arranged by its sections, and sessions arranged by the affiliated societies that meet with the Association. Some sessions are devoted to research reports and discussions in highly specialized scientific areas. Many others are of a wider, interdisciplinary character or explore relatively neglected areas between scientific fields. A number of college teachers have stated that they have come to rely on these symposia as excellent sources for updating their courses. One highlight is the annual AAAS general symposium under the title "Moving Frontiers of Science."

1959 Program Notes

At this year's Chicago meeting, the two sessions of "Moving Frontiers of Science" will consist of four lectures for the whole attendance: On the evening of 26 December, Sidney W. Fox (Oceanographic Institute, Florida State University) will speak on "How did life begin?" and William H. Pickering (Jet Propulsion Laboratory, California Institute of Technology) will speak on "How artificial satellites can help scientific research." On the afternoon of 27 December, the subject of R. E. Marshak (Department of Physics and Astronomy, University of Rochester) will be "Elementary particles of modern physics," and that of Wendell M. Stanley (Biochemistry and Virus Laboratory, University of California) will be "Genes, viruses, and cancer." Alan T. Waterman (National Science Foundation) will be chairman of both sessions.

For each remaining evening, the "special sessions" devoted to addresses also of general interest are as follows:

27 December. T. Keith Glennan (Administrator, National Aeronautics and Space Administration) under the auspices of the Tau Beta Pi Association.

28 December. Wallace R. Brode (science adviser, department of State), the AAAS retiring presidential address, followed by a reception.

29 December. Lee A DuBridge (president, California Institute of Technology), the joint annual address of the Society of Sigma Xi and the United Chapters of Phi Beta Kappa.

30 December. E. Wyllys Andrews (associate in archeology, Tulane University, and leader of the National Geographic Society's Dzibilchaltun expedition to the Maya ruins of Yucatan, Mexico), the National Geographic Society's annual premier illustrated lecture.

At intervals throughout the meeting period there will be 14 vice presidential addresses: Section A–Mathematics, R. H. Bing (University of Wisconsin), 26 December; B–Physics, Robert B. Lindsay (Brown University), 29 December; D–Astronomy, Dirk Brouwer (Yale University), 26 December; E–Geology and Geography, Byron N. Cooper (Virginia Polytechnic Institute), 29 December; F–Zoological Sciences, Herbert Friedmann (Smithsonian Institution), 29 December; G–Botanical Sciences, Frits W. Went (Missouri Botanical Garden), 30 December; H-Anthropology, A. Irving Hallowell (University of Pennsylvania), 29 December; I–Psychology, Frank A. Geldard (University of Virginia), 30 December; K–Social and Economic Sciences, Philip M. Hauser (University of Chicago), 27 December; L–History and Philosophy of Science, Herbert Feigl (University of Minnesota), 28 December; N–Medical Sciences, Nathan W. Shock (Baltimore City Hospitals), 30 December; Np–Pharmacy, Glenn L. Jenkins (Purdue University), 29 December; P–Industrial Science, Frank C. Croxton (Battelle Memorial Institute), 29 December; and Q–Education, Warren G. Findley (Atlanta Board of Education), 29 December.

Details of some 100 symposia sponsored by all 18 AAAS sections and by the participating societies in mathematics, chemistry, astronomy, geography, zoological sciences, botanical sciences, ecology, social sciences, history and philosophy of science, medical sciences, and education and science teaching will appear in subsequent issues of *Science*. The general scope of this year's Chicago meeting, the hotel headquarters of most of the participating organizations, and program notes have appeared in earlier issues [**129**, 1431 (22 May 1959); **130**, 226 (24 July 1959)].

Other features of the meeting are the large-scale exhibits of the Annual Exposition of Science and Industry, the AAAS Science Theatre with the showing of selected foreign and domestic scientific films, the annual meeting of the representatives of the 45 state and city academies of science that are affiliated with the Association, a conference on scientific manpower, and a conference on scientific communication.

In the past decade, the Association has increasingly recognized its responsibility to inform the general public about scientific developments and its obligation to assist all organizations concerned in the encouragement of qualified young people to prepare for, and enter, careers in science. The activities of the AAAS Pressroom and of the local Committee on Public Information—headed by Allen Center, vice president for public relations, Leo Burnett, Inc.—the broadcast coverage of the meeting, and the 13th annual Junior Scientists Assembly—a special program for a large number of selected high-school students, ar-

ranged by M. B. Sailsbury (Science Department, Evanston Township High School) at a site apart from the technical sessions—reflect these objectives.

In addition, a lecture especially for the interested public of the Chicago area will be given by George Gaylord Simpson (Museum of Comparative Zoology, Harvard University). The subject, commemorating the Darwin centennial but reflecting the current status of organic evolution, will be "The world into which Darwin led us."

An important aspect of any scientific meeting is the pleasure of seeing old friends and meeting new ones—and in reacting to the stimuli that surround one. Discussions, planned and impromptu, will be memorable. The 126th meeting of the Association—old in years but youthfully vital and expanding in activities—will be a rewarding experience.

Earlier Chicago Meetings

For those who like to recall or compare previous meetings of the Association in the same city, there have been six earlier Chicago meetings over a period of 91 years. The dates and other facts are summarized in Table 1.

Not all of these meetings were typical full-scale conventions of the AAAS. At the time of the first Chicago meeting, in 1868, the Association's membership, severely affected by the great struggle of 1861–65—when there had been no meetings at all—had declined from 1004 in 1854 to but 415 in 1867. The first two post-war meetings had been below average in attendance for the period. At the first Chicago meeting, however, the registration of 259 was considered gratifyingly large, with the number of papers exceeded only at the meeting of 1849; the membership of 686 represented a 65-percent gain over the low point of the preceding year.

The second Chicago meeting of 1907 had an official attendance of 725, though perhaps almost 2000 were present. The fourth and fifth meetings in that city, in June 1933 and September 1941, respectively, were extra summer meetings and, therefore, though their attendance was excellent for the time of year, they were not as large as the December meetings, with more societies participating.

The first Chicago meeting affords the greatest contrast with the present time because 91 years ago the Association was only 20 years old and the city of Chicago, which had been "surveyed into lots in 1830," was not much older. The city's population was about 250,000. Points of interest called to the attention of the visiting scientists included a University of Chicago (incorporated 1857, closed 1886), on Cottage Grove Avenue on land given by Stephen A. Douglas; Dearborn Observatory, which had the nation's largest telescope; the Chicago Academy of Sciences, then on Wabash Street between Van Buren and Jackson streets; Rush Medical College; the Board of Trade; the Stock Yards; Flint and Thompsons' Grain Elevators; and the Water Works, under construction "at a cost approaching one million dollars."

The Honorable J. Young Scammon was general chairman. The sessions were held principally in the Hall of the Young Men's Library Association, La Salle and Randolph streets, and in the lecture room of the First Baptist Church. The program was grouped in two general areas—Mathematics-Physics-Chemistry and Natural History—corresponding to the two original sections of the Association. The two principal addresses were made by astronomers. President Benjamin A. Gould delivered a comprehensive and eloquent summary of the life of Alexander D. Bache (1806–67), charter member and president of the Association in 1850. Bache, grandson of Benjamin Franklin's only daughter and leader of his class at West Point, is remembered for his long service as superintendent of the Coast Survey and as first president of the National Academy of Sciences. In his retiring AAAS presidential address, F. A. P. Barnard spoke on recent advances in science. Among the social events, the delegates enjoyed an excursion on the lake steamer *Orion*, an evening reception at the Tremont House, and instrumental music in Lincoln Park (reached by horse cars). There were longer side trips to Coal Valley near Rock Island, to the Lake Superior mines, and to the new prairie community of Omaha. A resolution of sympathy with the effort to resuscitate the Cincinnati Observatory was passed; another resolution favored the establishment of international copyrights.

The annals of the Association do not disclose why 39 years elapsed before the AAAS returned to Chicago, in December 1907. The present University of Chicago, founded in 1891, was host of the second Chicago meeting and Charles L. Hutchinson was general chairman. Most of the sessions were held on the campus but the housing was downtown. AAAS headquarters was in the Auditorium Annex at Michigan Boulevard and Congress Street and some nine other hotels were used by the 725 AAAS registrants and an additional 185 attending the sessions of participating societies. Room rates at the Palmer House and elsewhere were $1 to $2. Cafeterias were in existence. The one operated by the university's School of Education also served a table d'hôte lunch for 30 cents. As at present, the price of a hotel banquet could still equal the price of a night's lodging. The dinners of the naturalists and the astronomers were $1.75 and $2, respectively. (The AAAS registration fee, however, $3 then, is still unchanged in 1959.)

This 58th AAAS meeting was called to order by retiring president William H. Welch, eminent medical scientist of Johns Hopkins; the delegates were welcomed to the university and the city by Dean George E. Vincent and by George E. Adams, vice president of local committees. An appropriate response was made by the association's president, the celebrated physicist, E. L. Nichols, of Cornell University.

Among the 458 papers read were many excellent vice presidential addresses. As an example of the prominent scientists of a half century ago and their research interests, the following are listed:

Charles A. Conant, "Influence of friction in economics"

E. G. Conklin, "Mechanism of heredity"

Edward Kasner, "Geometry and mechanics"

W. C. Sabine, "Origin of the musical scale"

D. T. MacDougal, "Heredity and environic forces"

Clifford Richardson, "A plea for a broader education of the chemical engineers"

Simon Flexner, "Recent advances and present tendencies in pathology"

Elmer Brown, "The outlook of the section for education"

A. L. Kroeber, "The anthropology of California"

One panel discussion, timely and vigorous, was entitled the "Panic of 1907 and the monetary system of the nation." William H. Welch's retiring presidential address was "The interdependence of medicine and other sciences in nature." It was followed by a reception given by Henry Pratt Judson, president of the university. A particularly interesting symposium was "Cooperation in Biological Research" in which the speakers were Frank R. Lillie, William Trelease, H. H. Donaldson, Simon Flexner, W. H. Howell, and James R. Angell. The annual Biologists' Smoker was held at the Victoria Hotel, Michigan Boulevard and Van Buren Street.

Among the institutions visited were the Chicago Academy of Sciences, the John Crerar Library, the Field Museum of Natural History (then in Jackson Park on 57th Street), and the Art Institute.

The number of resolutions passed by the Council was larger than usual. Included were resolutions supporting various measures of President Theodore

Table 1. Earlier Chicago meetings.

Meeting No.	Date	President	No. of papers read	Attendance
17	1868, 5–12 Aug.	B. A. Gould	151	259
58	1907, 30 Dec.–4 Jan.	E. L. Nichols	458	725
73	1920, 27 Dec.–1 Jan.	L. O. Howard	1011	2412
92	1933, 19–30 June	H. N. Russell	1000	1341
109	1941, 22–27 Sept.	I. Langmuir	1436	2000
114	1947, 26–31 Dec.	H. Shapley	2019	4940

Roosevelt for the conservation of natural resources, for strengthening the National Bureau of Education, for the establishment of a research laboratory of tropical medicine on the Isthmus of Panama, and for setting up a series of seismological stations.

The third Chicago meeting (December 1920) was also held at the University of Chicago. J. Paul Goode of the university was general chairman, and L. O. Howard, great entomologist who had served the Association more than 20 years as permanent secretary, was in the chair as president.

This meeting, with the programs of 14 sections and 41 participating societies, was full-scale. More than 1000 papers were read, and the official registration of 2412 was substantially less than the actual attendance. It was at this meeting that the Visible Directory of Registrants, essentially in its present form, was inaugurated. These panels of directory slips, so convenient in locating other registrants, have since come into use at practically all large scientific meetings.

Most of the sessions were held in classroom buildings and the University Baptist Church but, again, housing was in the downtown hotels; the Congress was AAAS Headquarters. The retiring presidential address of Simon Flexner (Rockefeller Institute), "Twenty-five years of bacteriology—a fragment of medical research," summarized an eventful period of work in this field. An exhibit of the apparatus and principles of wireless telephony, prepared by the American Telephone and Telegraph and Western Electric companies under the auspices of the National Research Council, attracted many visitors.

In the business sessions, the Academies of Science of Michigan and Oklahoma became AAAS affiliates, and a collection of portraits and letters of all AAAS presidents, made by Marcus Benjamin of the Smithsonian Institution, was acquired by the Association. Resolutions were passed favoring the organization of Mexican scientists, deploring efforts to curtail the necessary use of animals in experiments, and advocating the preservation of wildlife by retention of roadside vegetation and some marshes.

The fourth Chicago meeting of 19–30 June 1933 was closely associated with the Century of Progress Exposition, the theme of which had been proposed by Michael Pupin, AAAS president in 1925. A primary purpose of the meeting was to review 100 years of developments in science. It was a "modern" meeting, with some delegates traveling by plane. According to an advertisement in the Program, one could fly from New York to Chicago in the "World's Fastest Multi-motor Planes" in only 5½ hours for $47.95. The journey from the Pacific Coast required 15 hours. The main AAAS registration was at the Stevens (now the Conrad Hilton) Hotel, but there were branch registration desks at the University of Chicago and the McKinlock Campus of Northwestern University.

There were 15 sections and 40 participating societies, and the official registration of 1341 was considerably below the attendance over the 12-day period. One factor may have been that the meeting places were widely distributed betwen the Exposition's Hall of Science, the university campuses, the Field Museum, the Adler Planetarium, the hotels, and other downtown buildings, so that even these registration points were not very convenient. The caliber of this exceptional summer meeting may be noted from the following partial list of the 28 official foreign guests and the distinguished American scientists invited to attend, and their papers, given in general sessions arranged by the sections of the AAAS:

J. J. Sederholm (Finland), "The progress and scope of Precambrian research"

Jacob Bjerknes (Norway), "Atmospheric soundings, methods, and results"

Morris Fishbein, Paul Dudley White, and Max Cutler, "A century of progress in medicine"

Enrico Fermi (Italy), "Theory of hyperfine structure"

F. W. Aston (England), "The story of isotopes"

R. A. Millikan, "New light on nuclear physics"

R. J. Tillyard (Australia), "The evolution of insects"

A. V. Hill (England), "Wave transmission as the basis of nerve activity"

Niels Bohr (Denmark), "Space and time in contemporary physics"

Richard Goldschmidt (Germany), "Some aspects of evolution"

C. U. A. Kappers (Netherlands), "The anthropology of the Near East in connection with its population"

Charles E. Spearman (England), "Recent advances in our knowledge of human personality"

Herbert John Gough (England), "Crystalline structure in relation to failure of metal: especially by fatigue"

The delegates were welcomed by Rufus C. Dawes, honorary general chairman of the 92nd AAAS meeting. Philip Fox, director of the Adler Planetarium, was general chairman of the local committees. In the absence of AAAS president Henry Norris Russell at Oxford University, retiring president John Jacob Abel, renowned pharmacologist of Johns Hopkins University, officiated and presided at the general banquet at the Stevens at which the foreign scientists were guests of honor and R. A. Millikan was toastmaster.

The Association's fifth Chicago meeting (September 1941) was the middle one of three meetings that year (one other was held in Durham, N.H. in June, the major one in Dallas, Tex., in December). The 109th AAAS meeting, commemorated the fiftieth anniversary of the founding of the present University of Chicago. The university had organized an impressive program of 12 special lectures and 35 symposia, 32 of which were jointly sponsored by the AAAS, under the theme, "New Frontiers in Education and Science." The speakers comprised some 100 visiting scientists and 50 members of the faculty. The five-session symposium arranged by Section N was devoted to aerobiology. Except for one at Yerkes Observatory and another at Madison, Wis., in advance of the AAAS meeting, the sessions were held entirely on the campus with registration in Ida Noyes Hall and accommodations in the residential halls and nearby hotels. There were approximately 2000 registrants.

The sixth Chicago meeting of December 1947 is still so recent that no detailed account is necessary. With programs by 15 sections and some 52 participating societies and 4940 registrants, the 114th meeting was the largest one, up to that time, in the long history of the Association, and it has since been exceeded only by the meetings of 1949, 1956, and 1958. As with other scientific meetings, the attendance curve is upward. In just the last 12 years, the Association has grown from 203 affiliates

and 33,000 members to 285 affiliates and 59,000 members.

The general chairman of the last AAAS Chicago meeting was Paul A. Jenkins, executive secretary of the Chicago Technical Societies. Harlow Shapley was president, and the late Forest Ray Moulton, formerly of the University of Chicago faculty, was administrative secretary. The retiring presidential address by James B. Conant was "The role of science in our unique society." The importance of science for any modern state and the problems of science in a democracy with the ideals and objectives of this country were clearly portrayed. In the receiving line at the reception which followed, besides those mentioned, were president-elect Edmund W. Sinnott and George D. Stoddard, president of the University of Illinois, who had welcomed the AAAS to Chicago.

Among the special sessions, under the auspices of the National Geographic Society, Harold F. Weaver spoke on the Brazilian eclipse expedition, and Bradford Washburn discussed cosmic rays from Mount McKinley; the annual address of the Society of the Sigma Xi was "The eight new synthetic elements," by Glenn T. Seaborg.

It was at this meeting that the AAAS Science Theatre was inaugurated and the Society of Systematic Zoology was founded by a steering committee that included G. W. Wharton, C. F. W. Muesebeck, Karl P. Schmidt, Waldo L. Schmitt, and A. S. Pearse. The Inter-Society Committee for a National Science Foundation met to review steps taken in 1947 to advise congressional committees of the attitudes of scientists. Dael Wolfle was secretary-treasurer; 42 representatives of member societies and 33 observers were present.

The Sherman Hotel was headquarters, and virtually all the 275 sessions were held there and in such other downtown hotels as the Blackstone, Congress, Continental, Palmer House, and Stevens. The Stevens was the site of the Exposition of Science. Among the 1947 exhibitors, to be present also in the larger 1959 Exposition, were the American Optical Company, Association of American University Presses, Central Scientific Company, General Biological Supply House, Graf-Apsco Company, Harper and Brothers, E. Leitz, C. V. Mosby Company, National Geographic Society, Philosophical Library, W. M. Welch Manufacturing Company, and John Wiley and Sons, Inc.

The winner of the Newcomb Cleveland Prize for that year was Harrison S. Brown, then of the University of Chicago, for his paper "Elements in meteorites and the earth's origin," read before a joint session of AAAS Sections D and E. The winners of the AAAS George Westinghouse Science Awards for newspapers and magazines were George A. Keaney, New York *World Telegram*, and Steven M. Spencer, *Saturday Evening Post*, respectively.

RAYMOND L. TAYLOR

AAAS

Forthcoming Events

November

9–11. American Petroleum Inst., 39th annual, Chicago, Ill. (API, 50 W. 50 St., New York 20.)

9–11. Association of Military Surgeons, 66th annual conv., Washington, D.C. (R. E. Bitner, AMS, Suite 718, 1726 Eye St., NW, Washington 6.)

9–11. Chemical Engineering, symp., Hamilton, Ontario, Canada. (Chemical Inst., 18 Rideau St., Ottawa 2, Ontario.)

9–11. Institute of Radio Engineers—Electronics Industries Assoc., fall, Syracuse, N.Y. (L. G. Cumming, IRE, 1 E. 79 St., New York 21.)

9–11. Instrumentation Conf., 4th, Atlanta, Ga. (W. B. Jones, Jr., School of Electrical Engineering, Georgia Inst. of Technology, Atlanta 13.)

9–12. Society of Exploration Geophysicists, 29th annual intern., Los Angeles, Calif. (B. Roberts, SEG, 1544 N. Highland Ave., Los Angeles 28.)

10–12. Electrical Techniques in Medicine and Biology, 12th annual conf., Philadelphia, Pa. (D. A. Holaday, College of Physicians and Surgeons, Columbia Univ., New York 32.)

10–15. Laboratory Measurement and Automation Techniques in Chemistry, intern. cong., Basel, Switzerland. (ILMAC, 61 Clarastrasse, Basel, Switzerland.)

11–12. Clinical Anticancer Drug Research, Washington, D.C. (B. H. Morrison, III, Cancer Chemotherapy National Service Center, National Cancer Inst., Bethesda 14, Md.)

11–13. Gerontological Soc., Detroit, Mich. (R. W. Kleemeier, Dept. of Psychology, Washington Univ., St. Louis 5, Mo.)

11–14. Society of Naval Architects and Marine Engineers, annual, New York, N.Y. (W. N. Landers, SNAME, 74 Trinity Pl., New York 6.)

12–13. Cardiology in Aviation, intern. symp., Brooks Air Force Base, Tex. (L. E. Lamb, Dept. of Internal Medicine, School of Aviation Medicine, Brooks Air Force Base.)

12–13. Operations Research Soc., natl., Pasadena, Calif. (D. A. Katcher, 4608 Morgan Drive, Chevy Chase 15, Md.)

12–13. Utilization of Atomic Energy, 2nd annual conf., College Station, Tex. (G. M. Krise, Radiation Biology Laboratory, Texas Engineering Experiment Station, College Station.)

12–18. International Odontological Session (with 64th Paris Dental Congress), Paris, France. (J. Charon, Secretary-General, 31, rue Tronchet, Paris 8°, France.)

15–18. Society of American Foresters, 59th, San Francisco, Calif. (Soc. of American Foresters, Mills Bldg., 17th and Pennsylvania Ave., NW, Washington 6.)

15–19. American Soc. of Agronomy, Cincinnati, Ohio. (L. G. Monthey, 2702 Monroe St., Madison 5, Wisc.)

15–20. Radiological Soc. of North America, conf., Chicago, Ill. (Radiological Soc. of North America, 815 Medical Arts Bldg., Fort Worth, Tex.)

16–18. Molecular Structure, 3rd conf., Houston, Tex. (Robert A. Welch Foundation, 2010 Bank of the Southwest Bldg., Houston 2.)

16–19. Magnetism and Magnetic Materials, 5th conf., Detroit, Mich. (D. M. Grimes, Dept. of Electrical Engineering, Univ. of Michigan, Ann Arbor.)

16–20. American Rocket Soc., annual meeting, Washington, D.C. (J. J. Harford, ARS, 500 Fifth Ave., New York 36.)

16–20. Automation Cong., 5th intern., New York, N.Y. (R. Rimbach, 845 Ridge Ave., Pittsburgh 12, Pa.)

16–21. Antarctic Symp., Buenos Aires, Argentina. (R. N. Panzarini, Instituto Antarctico, Argentino, Cerrito 148, Buenos Aires.)

16–21. Disposal of Radioactive Waste, conf., Monaco. (Intern. Atomic Energy Agency, 11–13 Kärntner Ring., Vienna 1, Austria.)

17–19. Building Research Inst. (NAS-NRC), fall conf., Washington, D.C. (J. H. Houtchens, Information Services, BRI, NAS–NRC, 1145 19 St., NW, Washington 25.)

17–19. Northeast Electronics Research and Engineering Meeting, Boston, Mass. (Miss S. Whiteker, Inst. of Radio Engineers, 73 Tremont St., Boston, Mass.)

17–20. National Assoc. for Mental Health, annual, Philadelphia, Pa. (American Psychiatric Assoc., 1700 18 St., NW, Washington 9.)

18. Association for Psychiatric Treatment of Offenders, New York, N.Y. (M. Schmideberg, New York Acad. of Sciences, 2 E. 63 St., New York 21.)

19–21. Inter-Society Cytology Council, annual, Detroit, Mich. (P. A. Younge, ISCC, 1101 Beacon St., Brookline 46, Mass.)

20–21. American Mathematical Soc., Winston-Salem, N.C. (J. W. Green, Univ. of California, Los Angeles 24.)

20–21. Nuclear Fusion, symp., Austin, Tex. (Texas Symp. on Nuclear Fusion, P.O. Box 8005, University Station, Austin.

22–24. American Soc. of Hematology, 2nd annual, St. Louis, Mo. (J. W. Rebuck, Henry Ford Hospital, Detroit, Mich.)

22–29. Pan American Child Cong., 11th, Bogotá, Colombia. (Office of Intern. Conferences, Department of State, Washington 25.)

23–24. Solid-State Techniques in Modern Instrumentation, symp., Philadelphia, Pa. (G. L. Eberly, 12 S. 12 St., Philadelphia 7.)

23–25. Fluid Dynamics (APS), Ann Arbor, Mich. (R. J. Emrich, Dept. of Physics, Lehigh Univ., Bethlehem, Pa.)

23–26. Technical European Conf. on Standards Applicable to Water (by invitation only), Copenhagen, Denmark. (World Health Organization, Regional Committee for Europe, 8 Scherfigsvej, Copenhagen.)

(See issue of 18 September for comprehensive list)

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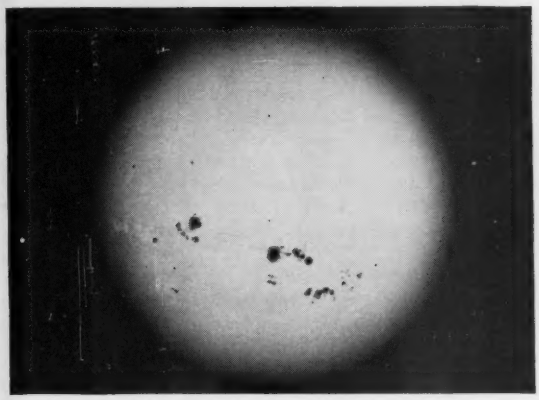
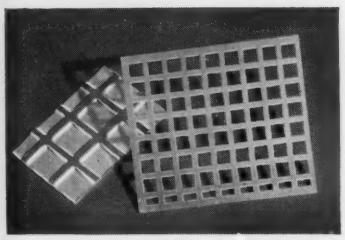


This picture of the solar disk with sunspots and bright faculae was taken on *Kodak Autopositive PB Film* at the prime focus of a 6-inch *f*/15 reflecting telescope at 1/100 second without a filter or any interposed optics. The ¾″ negative image can stand a lot more enlargement. Alas, there is no room for that here, or for an explanation of why this particular film was chosen. To read all about it, send for a preprint of "Photographing the Sun" to Eastman Kodak Company, Special Sensitized Products Division, Rochester 4, N. Y. If you've made a reflecting telescope and sometimes wonder why, you may find a soul-satisfying answer in that article.

The space here must serve more pressing needs having to do with another product called "Autopositive," the new *Kodagraph Autopositive Projection Paper*. This paper you put in an enlarger or copying camera and use for reproducing drawings or documents at any desired magnification or minification. Black photographs black, and white photographs white. The negative-to-positive jazz is avoided, and even the conventional hypo fixing bath is replaced by a jet of plain water. For information on where to buy it and how to use it, write Eastman Kodak Company, Graphic Reproduction Division, Rochester 4, N. Y.

Photo-milling



New methods of metalworking do not come along often enough to be ignored. Here are two examples of what we call "photo-milling." The one on the right could, of course, have been done on a punch press if die cost had been justifiable. No die was used, nor were the openings cut individually. The one on the left looks like a milling machine job, for sure. It isn't.

This sort of thing is now best done photographically with a new light-sensitive preparation called *Kodak Metal-Etch Resist*. You spray it on, or dip, and dry. Then you expose to bright light under a film on which you have photographed the pattern. After a simple development, a flush that washes away the resist where the pattern kept the light off, and a bit of baking to remove the developer solvent, the metal is ready for whatever chemical or electrolytic etching works best. The resist protects from etching action vigorous enough to remove a quarter-inch of aluminum and considerable depth of stainless steel, tool steel, magnesium, titanium, and possibly some metals we know nothing about. To get the benefit of our thinking on the subject, write Eastman Kodak Company, Graphic Reproduction Division, Rochester 4, N. Y.

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$$COCl_2 + C_6H_5OH \rightarrow ClCOOC_6H_5 + HCl$$

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We, in turn, try to understand the customer's situation. Many a chemist just as capable as we of selecting and running the above reaction would just as soon not have a small tank of phosgene next to his file cabinet. (If there is one thing that's more of a burden to have around than a tank of phosgene, it's half a tank of phosgene.)

Here the phosgene (Small tanks, thank you; we're timid.) doesn't sit around long. There must be fifty compounds we make from phosgene —chloroformates, where we replace one of phosgene's chlorines, e.g. the newly added *p-Nitrobenzyl Chloroformate* (Eastman 7819); carbonates, where we replace both chlorines; isocyanates, where we go

$$RNH_2 + COCl_2 \rightarrow RNCO + 2\ HCl$$

Come to think of it, we'll take a back seat to nobody, spotless or otherwise, on cleverness with phosgene.

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■ CONTINUOUS-FLOW ENLARGING CAMERA accepts originals, which may be opaque or translucent and up to 15 in. wide, either continuously or intermittently. Six enlargement ratios from 2 to 7 are provided. The optical system includes a series of mirrors and a lens. The image is reflected from the surface of the original as the latter moves continuously across a lighted slot at a speed proportional to the enlargement ratio. Sensitized paper passes through the copying point at a fixed speed of 10 ft/min. (Peerless Photo Products, Dept. 124)

■ RECORDER of optical galvanometer type produces a directly visible record immediately at low recording speeds and within 10 sec at high speeds. An ultraviolet source and a special photographic paper are used. The record is stable for weeks under ordinary room illumination and can be fixed by standard methods for permanence. Units with up to 12 channels are available. Writing speeds up to 10,000 in./sec can be attained. (C. H. Stoelting Co., Dept. 125)

■ CORROSION MEASURING INSTRUMENT automatically records corrosion as it occurs. Corrosion is detected by measurement of the ratio of resistance of exposed and protected metal elements mounted on a probe that extends into the corrosive medium under test. The two elements form two arms of a bridge circuit balanced by a servo-driven potentiometer. Range of the recorder is 10 μin. of corrosion (full scale); totalizer dials permit indication of corrosion up to 1000 μin. Balancing and printing are accomplished in 1 min. (Magna Products, Dept. 127)

■ TEST FURNACE of gas-fired type develops temperatures from 2000° to 4300°F. Refractories are made of zirconium oxide. Burners do not require water cooling and operate on natural, liquified-petroleum, or manufactured gas. Preheated air is used for temperatures above 1800°F, and oxygen enrichment permits achievement of temperatures above 3800°F. The furnace is said to be especially useful for testing components such as thermocouples that might be affected by stray currents if an electric furnace were used. (Hirt Combustion Engineers, Dept. 132)

■ STANDING-WAVE DETECTOR measures impedance and voltage-standing-wave ratio from 100 to 1000 Mcy/sec. Specifications include residual voltage-standing-wave ratio less than 1.03; minimum input signal approximately 1 volt at 100 Mcy/sec, 0.1 volt at 1000 Mcy/sec; characteristic impedance 50 ohm. Reactive component sign and voltage-standing-wave ratio are read directly. (Polytechnic Research and Development Co., Dept. 119)

■ VOLTAGE-TO-TIME CONVERTER permits a 1-Mcy/sec counter timer to be used as digital voltmeter. Input voltages from ± 1 mv to ± 100 volts are accepted. Output is two pulses timed to be directly proportional to the d-c input voltage. Conversion with automatic polarity indication is accomplished within 10 msec. Accuracy is said to be 0.05 percent. Addition at a r.m.s.-to-d-c converter permits measurement of a-c voltage. (Systron Corp., Dept. 120)

■ CHROMATOGRAPH permits either isothermal operation or controlled, programmed increase of the temperature of the column during a run. Nine heating rates from 3.3° to 48°C/min are provided. Cooling from 400° to 40°C can be accomplished in 7 min. The preheater is controlled independently to 500°C, and the thermistor detector is maintained at a constant temperature of 300°C. (F & M Scientific Corp., Dept. 108)

■ METAL LOCATOR for tracing metal pipes and cables includes a transistorized receiver and transmitter, each powered by four flashlight cells. Controls allow adjustment for variation in the conductivity of soil. As stated in the manufacturer's specifications, maximum detecting range is 22 ft and maximum tracing range is 300 ft. The equipment measures 11 by 14 by 8 in. and weighs 12 lb. (Gardiner Electronics Co., Dept. 121)

■ QUARTZ-TUBE VACUUM FURNACE is designed for heat-treating, melting, or sintering operations at temperatures up to 3000°C and pressures of the order of 0.01 μ-Hg. The pumping system includes a 6-in. oil diffusion pump with a water-cooled or refrigerated cold trap. A shielded sight port permits observation and temperature measurement. High-frequency power supply and controls for heating are optional items. (Vacuum Specialties Co., Dept. 122)

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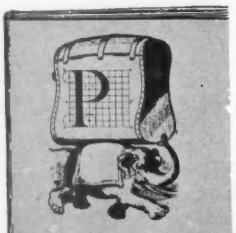
JOSHUA STERN
National Bureau of Standards, Washington, D.C.



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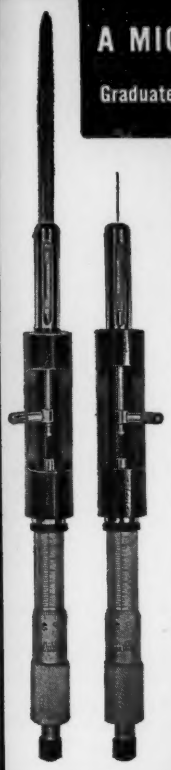

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Letters

(Continued from page 892)

method of "dichotomy," as more thorough consideration of the article would reveal. However, as described in the article, the logical computations involved are of necessity far more complicated than the simple example Kunin gives in his letter. The references to Kemeny, Ashby, and Culbertson noted by Kunin are exceedingly superficial remarks which, in essence, claim that logic is good and useful. In our article we attempted to go somewhat further, to present an introduction to the means by which logic can be utilized and integrated with other mathematical disciplines into a multistage decision process. Kunin's remark is analogous to telling a physicist that mechanics is based on Newton's laws. This we know; the problem is how to apply them. Algorithms for the more complicated logical computations are given in references 5, 6, and 7 of our article. [See, for example, R. S. Ledley, *Digital Computer and Control Engineering*, McGraw-Hill, New York, in press.] Note however that in its simplest form the "conditional probability or learning device" described in the article is in a sense a "logic machine" as well as a probability machine.

R. S. LEDLEY
Washington, D.C.

L. B. LUSTED
Rochester, New York

Struggle and Stimulus

The recent editorial by Warren Weaver, "Dither" [*Science* **130**, 301 (7 Aug. 1959)] is highly interesting and perhaps reflective of something deeply significant.

It is common to look at situations like the complete absence of friction or the complete absence of invasion of the human body by afflictions of any sort, as the optimum toward which to work. The heaven of which one dreams is one devoid of all adversity—a place where wants are fully and constantly satisfied.

But can it be so? Weaver points out a function of irritation. Some evidence persists that optimum "health" is a state of successful struggle against organisms; that from such struggle the body gains a quality it would not otherwise attain. Economic endeavor, a persistent battle against want which can never be completely won, may be useful therapy against a sense of futility. A life totally devoid of need and struggle and choice, in other words, describes a hell rather than a heaven.

F. A. HARPER
San Mateo, California

Warren Weaver's editorial pleases me because it seems to go along with my own ideas on overspecialization in this world of ours. It is useful to see the woods sometimes as well as the trees.

I should like to go even farther than he does and say that some town ought to invest more money in training and hiring its teachers for the first four grades of elementary schools than it does for its high schools. The young mind, stimulated by the exciting new ideas of our present world, ought to be trained to work and think efficiently during the enthusiastic days of its first discoveries. Years of wasted time could be saved for many of our coming scientists.

Our fabulously rich foundations give millions to colleges. This is to be commended, but they could be missing their great chance. Whatever our children accomplish in their lives, their accomplishments will be greater if they learn to think at 6 instead of 16.

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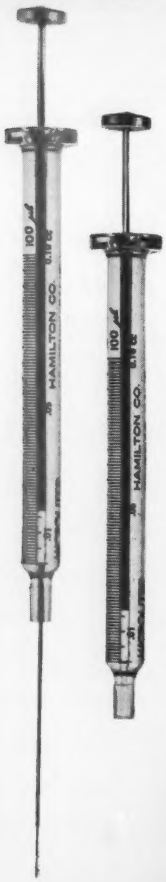

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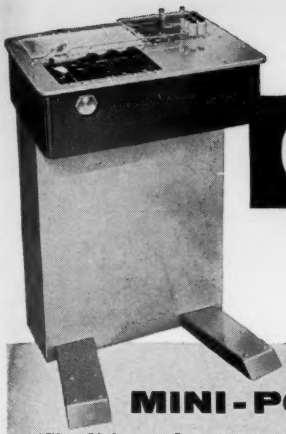

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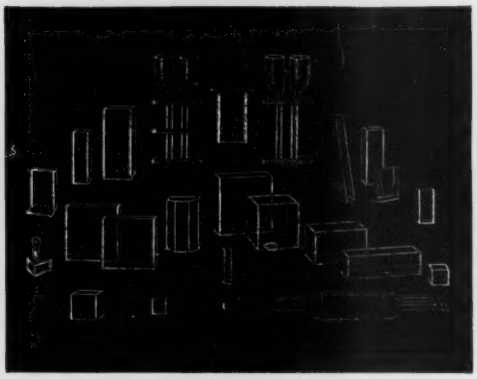

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The General Program of the 126th Meeting of the AAAS in Chicago, 26-31 Dec., 1959, will be available to you within the first week in December—whether you can attend the Meeting or not.

Effective this year, the former General Program-Directory, which had become an unwieldy book of more than 400 pages, has been separated into *two* publications, namely:

a) The Directory of AAAS Officers and Activities, 96 pp., already published; and
b) The General Program of the Annual Meeting, c. 200 pp., which will appear early in December

Both of these, sold at cost, may be purchased separately—in advance (see coupon below), or at the meeting. Some of their *respective* contents are:

The General Program

1. The two-session general symposium "Moving Frontiers of Science IV," arranged by the Committee on AAAS Meetings.
2. Programs of the 18 AAAS sections (symposia and contributed papers).
3. Programs of the more than 80 participating societies.
4. Sessions of the Conference on Scientific Communication, Conference on Scientific Manpower, and the Academy Conference.
5. The Special Sessions: AAAS Address and Reception, National Geographic Society, Phi Beta Kappa, Sigma Xi, RESA, Tau Beta Pi Association.
6. Details of the Morrison Hotel—center of the Meeting—and of the other session sites.
7. Titles of the latest foreign and domestic scientific films to be shown in the AAAS Science Theatre.
8. Exhibitors in the 1959 Annual Exposition of Science and Industry and descriptions of their exhibits.

The Directory

1. AAAS officers, staff, committees, for 1959.
2. Section committees and other AAAS Council members.
3. The 285 affiliated organizations.
4. Historical sketch and organization of the Association.
5. Complete roll of AAAS presidents and their fields.
6. Publications of the Association, including all symposium volumes.
7. AAAS Awards—including all past winners.
8. Future Meetings of the AAAS through 1963.
9. New and current activities of the AAAS.
10. Constitution and Bylaws.

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B.S. or M.S., Biochemistry. Routine and special chemistry in hospital laboratory. Applications to include training, photo, and expected salary, Augustana Hospital, 411 W. Dickens Ave., Chicago 14, Illinois. X

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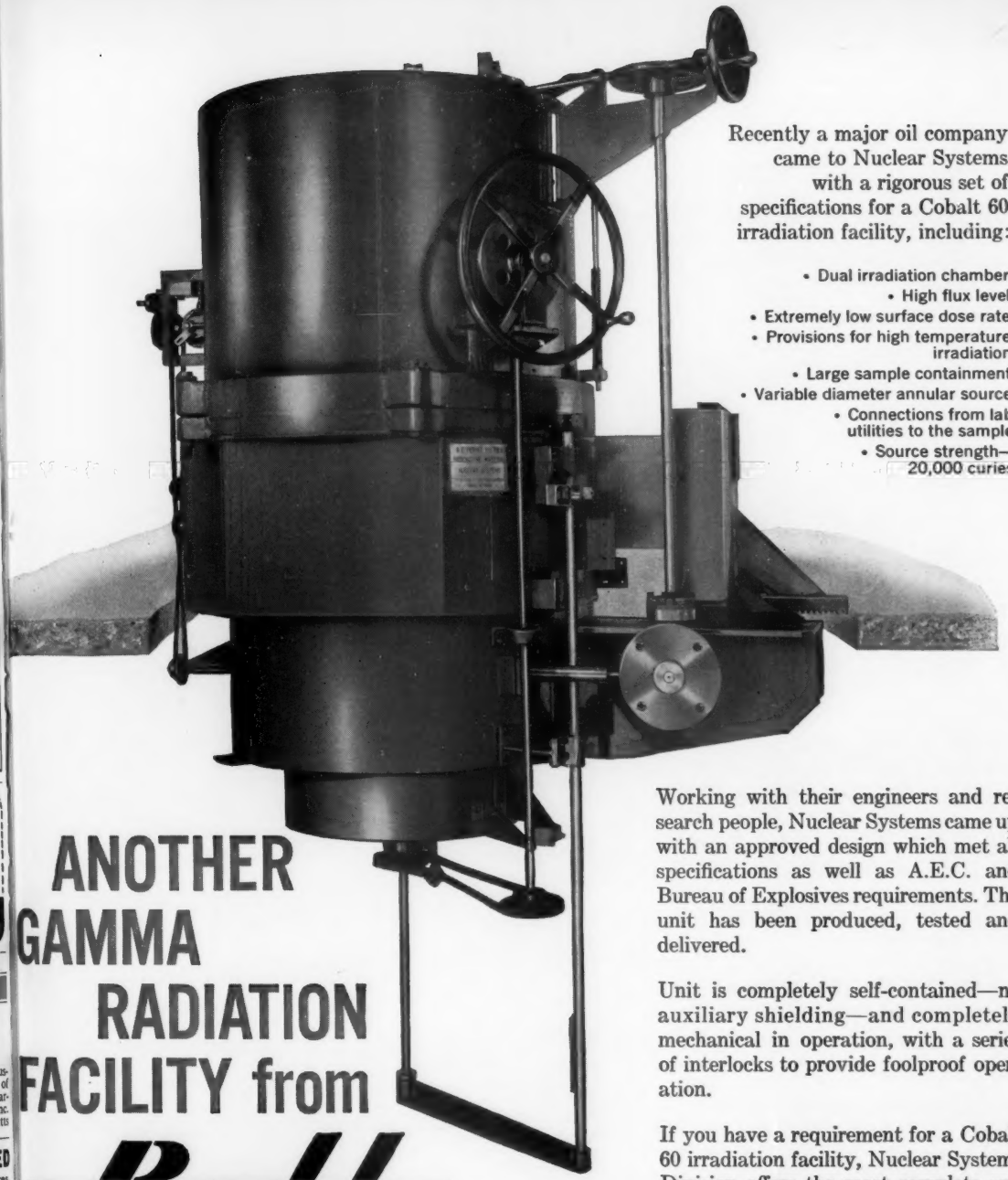

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